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THE TARIFF SITUATION

Following the hearings in March, the Tariff Commission recommended to President Kennedy that (1) no tariff increase be made on rolled glass and (2) substantial tariff increases be made on sheet glass. On June 29 the President postponed a final decision on sheet glass, asking the Commission to gather more information.

The following report reviews the testimony at each hearing pro and con tariff increases and presents President Kennedy's reasons for deferring his decision until a later date.—Ed.

Have sheet glass and rolled glass imports under foreign trade agreements been seriously injuring the domestic industry? Should tariff rates be hiked to protect U.S. producers?

Statements on this subject have been forthcoming in recent months from U.S. manufacturers, importers, jobbers, union representatives, congressmen, the Tariff Commission and finally—in the case of sheet glass—the President of the United States. The result thus far: tariffs on rolled glass will remain unchanged. Those on sheet glass are still under discussion.

Domestic manufacturers told the Tariff Commission that the onslaught of foreign imports threatens to reduce the window glass business here to a marginal and dying operation. They spoke of a demoralized market and mounting inventories, unemployed workers and silent plants. And they blamed low-wage, low-priced foreign competitors.

Importers, on the other hand, contended that foreign glass has not only filled a need but has actually opened up new markets in this country. They cited cost items favorable to domestic producers, who, they asserted, promote more lucrative plate glass because of heavy investments in such facilities. Similar arguments were advanced in the case of rolled glass. Full tariffs, required on imports from Communist-dominated countries, were not at issue.

After 4 days of "escape clause" hearings on sheet glass, March 14-17, the Commission unanimously found that the U.S. producers had the best of the argument. The 6-man agency by a 4 to 2 vote recommended substantial tariff increases to President John F. Kennedy on May 17. (The two who disagreed—commissioners Glenn W. Sutton and Walter R. Schreiber—voted for even higher rates.)

After similar rolled glass hearings on March 28 and 29, however, commissioners J. Weldon Jones and William E. Dowling joined chairman Joseph E. Talbot in a finding of no domestic injury stemming from imports under trade agreements. Therefore, no tariff increase on rolled glass was recommended to the President.

When the Commission is thus split 3 to 3, a recommendation is usually made. Rolled glass was an exception because the commissioners who voted for an increase were also divided among themselves. All three found injury. But vice-chairman J. Allen Overton, Jr., urged a steeper rate hike than commissioners Sutton and Schreiber.

President Kennedy, after studying the sheet glass report, announced on June 29 that he had decided to postpone a final decision until the Commission could gather more information. "In reaching this conclusion, I have been assisted and advised by the Trade Policy Committee," he told the Commission in a letter. (The

Committee, consisting of the heads of several executive departments or their alternates and chaired by the Secretary of Commerce, advises the President on trade negotiations like those which started last fall at Geneva under the General Agreement on Tariffs and Trade [GATT].)

That same week Sen. Styles Bridges (Rep., N.H.) introduced a bill in Congress that would make Commission recommendations binding on the President. The bill has been referred to the Senate Finance Committee. However, because all revenue measures must originate in the House, little can come of the move independently until a member of the House introduces a parallel measure there. In view of this, Sen. Bridges said in a floor speech that he intends to offer his bill as an amendment to another House-passed bill if none like his is introduced. Several other senators rose to express approval of Bridges' action, and the glass industry was mentioned as one of those most deserving attention.

production, in terms of major points of shipment," since "the report provides such data for imported products only." His letter continued, "I would appreciate an elaboration upon the suggestion that there have been restrictive sales practices by domestic producers, in order that I may determine what effect, if any, these practices have had upon imports. It would also be useful to study the relationship of domestic shipments to general economic trends, particularly with respect to those in the construction and automobile industries. "In addition, I should like any information available on the pricing practices employed by those selling the sheet glass that is imported."

The hearings themselves grew out of 1960 "peril-point" proceedings before the Commission in connection with 2400 items proposed by the White House for this year's international negotiations. The Commission determines the tariff point below which imports will seriously injure the domestic industry. If the current

U. S. Imports of Flat Glass by Type and Principal Country of Origin*
1959 — 1960 (Dollar Value)

Type	United Kingdom	Belgium	France	West Germany	Japan	Other	Total
1960							
Cylinder, crown and sheet	3,135,806	9,585,360	3,168,112	3,327,373	3,964,748	5,001,315	28,182,714
Plate	1,307,310	10,921,141	2,778,155	1,538,560	419,870	307,849	17,272,885
Mirror	38,924	788,781	6,653	1,793	—	25,487	861,638
Rolled	124,765	2,290,990	251,023	213,989	718,291	511,319	4,110,377
Laminated, etc.	379,014	9,305	31,331	410,907	690	29,017	860,264
Total	4,985,819	23,595,577	6,235,274	5,492,622	5,103,599	5,874,987	51,287,878
1959							
Cylinder, crown and sheet	4,684,338	12,018,186	4,022,564	3,819,158	4,531,321	5,334,224	34,409,791
Plate	3,430,725	9,090,075	2,779,692	1,945,684	252,126	518,696	18,016,998
Mirror	62,105	957,270	9,108	19,733	5,266	42,472	1,095,954
Rolled	252,005	2,308,736	203,696	207,772	683,576	247,656	3,903,441
Laminated, etc.	324,089	19,642	39,298	297,614	3,900	1,332,631	2,017,174
Total	8,753,262	24,393,909	7,054,358	6,289,961	5,476,189	7,475,679	59,443,358

*Prepared in Consumer Durable Goods Division, Business and Defense Services Administration, U. S. Department of Commerce, June 1961.

The White House action is not unprecedented. The Commission, as it has in the past, is now going about obtaining the information which the President requested. On July 7, Commission secretary Donn N. Bent issued a notice saying that "interested parties wishing to submit written statements or briefs . . . may do so . . . within 60 days." He added that "no public hearings are being scheduled," but did not rule them out entirely.

"It would be useful to have a more complete analysis of the impact of pricing practices by domestic and foreign producers upon the share of the market captured by imports," Kennedy's letter stated. "I would also like information on the profit relationship to investment in productive facilities."

In addition, the President asked the Commission to report upon "the effect of domestic technological innovations and automation." He said that it would be "helpful to have average unit price data for domestic

tariff is below this point, "escape clause" hearings automatically ensue. Such has been the case with both sheet and rolled glass. At present, all tariff agreements with other nations must contain an escape clause for protection of domestic industry.

"The escape clause proceedings," the Kennedy letter noted, "are designed to provide relief whenever there is a serious injury, or threat of serious injury, to any domestic industry, resulting from a tariff concession. When fairly and objectively implemented, this provision permits domestic producers to compete on an equitable basis with those supplying similar products from abroad.

"However, we must be certain that the use of this provision is constructive without being excessive, that it prevents serious injury to domestic producers without unduly restricting fair competition, and that it permits domestic manufacturers to obtain redress without jeopardizing the national interest. Any data which the

Commission deems relevant to this determination should be included in the report."

The following is part of the general sheet glass picture presented to the President by the Commission in its first offering.

Year	U. S. Consumption (Million Lb.)	Per cent Share Supplied by U. S. Producers	Imports at GATT rates (Million Lb.)
1950	1,465.0	97.8	32.2
1954	1,404.4	92.2	109.8
1955	1,830.0	86.6	238.5
1960	1,670.9	75.4	391.3

The Commission found that sales of domestically produced glass decreased by $30 million, or about 25 per cent, between 1955 and 1960, that 1960 production represented use of only about half domestic plant capacity, and that year-end inventories were nearly double the quantities on hand at the end of either 1954 or 1955. Several other findings were also noted.

1. Between 1955 and 1960 the average number of production and related workers dropped 16 per cent; total manhours worked, 17 per cent.

2. Total wages paid did not change significantly despite an increase of 22 per cent in average hourly wages.

3. Sale of imported glass at lower prices seriously weakened the domestic price structure.

4. Since November 1, 1959, domestic producers, despite rising material and labor costs, have had to reduce prevailing prices in areas like New York, Boston, Los Angeles, and Miami.

5. The aggregate net operating profit (before income taxes) for six concerns in 1955 (accounting for nearly all the domestic output) was $30,056,000; in 1960 four concerns accounting for the bulk of domestic output showed a net operating loss of $1,165,000.

6. An increasing proportion of imports consist of larger stock and staple sizes, while an increasing proportion of domestic sales are of small, special-cut sizes. This increases unit labor costs and glass-cutting losses for domestic plants.

The Commission said best Census Bureau figures show window glass exports are less than half of one per cent of total U.S. production. This glass goes chiefly to Canada, Latin America, and the Scandinavian countries. Imports, on the other hand, come from the following sources.

Countries	Lb. Imported in U. S. 1955	1960
Belgium	92,060	150,009
Japan	22,421	54,236
West Germany	20,608	42,658
France	28,792	34,452
United Kingdom	21,274	44,834
Italy	6,045	12,470
All Other	47,330	52,659
	238,530	391,318
Communist-Dominated Countries at Full Duty	6,733	19,186
Total	245,263	410,504

The Commission cited these principal factors leading to the import trend.

1. Substantially lower prices for imported glass than for a similar U.S. product.

2. Periodic shortages, actual or threatened, in U.S. production.

3. Availability of thinner and cheaper single- and double-strength glass from foreign manufacturers.

4. Reluctance of U.S. producers to bypass their direct factory-distributor customers in order to sell directly to other large volume distributors and industrial users.

Based on its findings, the Commission recommended to President Kennedy this GATT modification.*

Glass Measuring in Sq. In.	Present Rate per Lb.	Recommendation
Not over 384	.7¢	1.3¢
Over 384 and not over 864	.9¢	1.6¢
Over 864 and not over 2400	1.1¢	1.9¢
Over 2400		
Weighing not over 28 oz. per sq. ft.	1.4¢	2.4¢
Weighing over 28 oz. per sq. ft.	1.4¢	3.5¢

Sheet glass that is colored or specially processed is presently subject to an ad valorem duty in addition to the specific duty. Under GATT, the 1930 rate of 5 per cent was reduced to 2½ per cent in 1951. No change was recommended in the Commission's report. The report also pointed out that in 1955 about 8 per cent, by weight, of the imports dutiable under the regular tariff were also subject to the ad valorem rate. By 1960 this proportion had dropped to 1 per cent.

On rolled glass, the Talbot-Jones-Dowling report found domestic production dominated by the Mississippi Glass Co. and the American-Saint Gobain Corp., controlled by the Saint Gobain Co. of France. These two firms control industry pricing, the report said, and confine their sales to factory-recognized buyers; as a result, many dealers and jobbers have been forced to import.

U.S. rolled glass producers increased their prices by more than 40 per cent during the 1955-1960 period, according to the report, "although their profit margins were generally favorable."

Among other things, the report mentioned these factors affecting U.S. producers: *(1)* an increase at full duty of imports from Communist-dominated countries, *(2)* the response of the flat glass market to fluctuations in building construction, *(3)* competition with plastics products and *(4)* business recessions.

On the subject of window glass sales outlets, mentioned in the Kennedy letter, the Commission had this to say:

"The U.S. producers sell their glass to carefully selected distributors and jobbers, to fabricators such as sash and door and jalousie manufacturers, and to processors such as temperers, laminators and mirror manufacturers. These so-called reorganized factory buyers, selected according to the judgment of the individual producers, are the only concerns that can buy sheet glass directly

*Glass weighing not over 4 oz. per sq. ft. excepted.

from the factory. Other concerns desiring to purchase sheet glass, even in carload lots, must order their glass from the recognized factory distributors at correspondingly higher prices.

"Under this distribution system the glass may be sold down through succeeding business levels (and at correspondingly higher prices) beginning with the recognized factory buyer and followed by the smaller distributor or jobber, the dealer, and the retailer. The processor and fabricator, and the building and glazing contractors, depending on their size, buy at different levels. The direct factory buyer classification, however, is carefully controlled by the U.S. producers.

"As a result of this control, jobbers and distributors that are not recognized factory buyers (even though they may purchase in carload quantities) have to compete with the distributors and jobbers that are so recognized and from whom they are forced to buy their glass.

"This element of competition between the higher and lower levels of distribution of domestic glass has encouraged the importation of sheet glass. Those firms at the lower level of distribution can import directly at the same price levels as the domestic factory buyers and can thus compete with the latter on equal terms."

In support of the domestic industry the Commission heard Rep. Overton Brooks (Dem., La.), Cleveland M. Bailey (Dem., W. Va.), William G. Bray (Rep., Ind.), James W. Trimble (Dem., Ark.) and Ed Edmondson (Dem., Okla.). A statement was received from Rep. John Dent (Dem., Pa.). All spoke in behalf of glass manufacturers in their areas.

Lead-off witness for U. S. producers was president George P. MacNichol, Jr., of Libbey-Owens-Ford Glass Co., Toledo, O. MacNichol recalled that his company pioneered that distinctive mark of suburbia, the picture window. "Libbey-Owens-Ford invested millions of dollars in such market expansion programs, an investment now being sacrificed to foreign manufacturers, who, contributing nothing to the increased American demand for window glass, used their low-wage advantage to undersell American producers," he said.

MacNichol described price maneuvering between his firm and foreign competitors which he said showed "the utter futility of trying to meet prices established by foreign competitors." He pointed out that the average wage rate in LOF sheet glass plants, including most fringe benefits, has risen from $2.98 per hour to $3.67 per hour between 1955 and 1960.

James L. Williams of Pittsburgh, vice-president, manufacturing, of American-Saint Gobain Corp., said the attitude of customers is this: "If it's just sheet glass, buy it abroad; if it must be special, buy it at home." According to Williams, 50 per cent of the volume of the company's Arnold, Pa., plant is produced to fill special quality requirements. "We can't live on this type of business," he added.

Williams testified that his company is building a new $40 million plate glass plant in Kingsport, Tenn., to make the firm a full-line producer. "Even with a full line of products in sight, our prospects are considerably dimmed by reason of the current flood of imported glass of all types into our domestic market," he said. He pointed out that the company's sheet glass operations were conducted at a loss in 1960.

President Russell Rice of the Fourco Glass Co., Clarksburg, W. Va., and Robinson F. Barker, vice-president and general manager of the glass division, Pittsburgh Plate Glass Co., followed with similar testimony.

"Destructive competition from sheet glass imports," said Rice, "became a burden to the domestic industry in the mid-fifties and now bids fair to reduce it to a marginal and dying American industry."

He stated that the cost-price squeeze is reducing or eliminating his company's profit margins "at a rate which will, with further cost increases, leave us without earnings for our stockholders. Neither will we have the means to maintain and improve our plants to reduce costs as far as efficient equipment would make this possible." Rice added that the big loss of customers has previously occurred in the coastal areas, but since the opening of the St. Lawrence Seaway, his company is beginning to lose heavily in the midwest.

According to Barker, the principal reasons for the penetration of the domestic glass market by foreign producers are that *(1)* foreign firms are equal in technology, labor skills, and productivity, *(2)* ocean freight rates are no barrier to imports, *(3)* foreigners have a cost advantage in both labor and raw materials, and *(4)* tariffs are ineffectual. Barker told the Commission "the limb on the family tree that represents our sheet glass part of the industry is withering and withering fast."

Wayne E. Harding, Jr., of Topeka, Kan., president of the Flat Glass Jobbers Assn., said his members buy from both domestic and foreign manufacturers, and urged "an absolute country quota." He said many distributors are operating at a substantial loss. Harding was supported by Sydney Silverstein, Architectural Glass Products, Inc., Miami, and Arthur Balik, vice-president of Max Balik's Sons, Inc., New York.

Enoch R. Rust, international second vice-president of United Glass & Ceramic Workers of North America (AFL-CIO), testified that membership dropped from 57,000 to 36,000 in a period of about 2 years. The union wants "fair protective quotas that will not destroy our friends abroad but will protect the American market and the American worker," he declared. Supporting testimony came from Howard P. Chester, national president of the Window Glass Cutters League (AFL-CIO), Columbus, O., and Raymond A. Lorant, Sr., secretary-treasurer of that organization.

Peter H. Schor, president of North-Town Glass Co., Chicago, said his company is in "serious condition due to [imported] glass being delivered in the Chicago area."

Speaking in behalf of imports was president Rene Lambert of Industrial Sales, Ltd., Montreal, a Belgian representative. Lambert said he has been selling Belgian

(*Continued on page* 469)

Sequential Analysis in Quality Control of Glass Containers

by ***Robert J. Sheffler,*** Revlon, Inc.

The sequential analysis of attributes is presently employed by Revlon, Inc., to assure the functional and aesthetic properties of its products. The principles of this approach to quality control, discussed here on the basis of experience with the I-S machine, can be applied effectively to any operation with sound economic advantages, provided that they are used intelligently.

Acceptance sampling and inspection of glass containers is being promoted rapidly as standard practice among manufacturers of foods, beverages, pharmaceuticals, and toiletries. Specific sampling and inspection plans and the appropriate operating characteristics curves may be obtained from the customer in most cases so that the container manufacturer is provided with the means to evaluate his ware on the same basis. The particular plan may be defined by one or both of two methods.

1. The customer's incoming component inspection department selects a certain number of samples n from the lot. The lot is accepted if the acceptable number of defectives c is *not* exceeded when n number of samples is examined. If more than c defectives are found, the lot is rejected.

2. The acceptable quality level (AQL) and the lot tolerance per cent defective (LTPD) are specified.

The AQL is an oft-quoted term that is misinterpreted almost as frequently as it is used. In order to understand the meaning of AQL and LTPD, one must recognize first that when a sample is selected from a lot of ware to represent the ware, the container manufacturer and the customer are exposed to certain definable risks. The glass container producer suffers the risk that the ratio of defective glass to acceptable ware in the sample may be greater than that true ratio which actually exists in the shipment. It follows that the customer will decide incorrectly to reject the shipment. The risks of making this wrong decision to return good ware are reduced as the sample size increases and as the true per cent defective ware in the lot decreases. Once the sample size n and the acceptance number c are established, the container manufacturer's risks of having good ware rejected may be defined mathematically. The producer's risk often is expressed as the acceptable quality level (AQL) which is that true per cent defective in the high quality lot which will be accepted by the customer 95 per cent of the time; *e.g.*, if a property of an attribute acceptance sampling plan is a 1.5 per cent AQL, approximately 95 out of 100 lots of containers shipped to the customer, in which the true per cent defective is 1.5 per cent, will be accepted—5 shipments will be rejected.

Similarly, the customer suffers a converse risk that the ratio of defective glass to acceptable ware in the

sample may be less than the actual ratio which exists in the lot. Under these circumstances the customer will decide incorrectly to accept the shipment. As before, the risks of making *this* wrong decision to accept substandard ware are reduced as the sample size increases; however, the wrong decision to accept an inferior lot will be lessened with an increasingly greater incidence of defective ware. The consumer's risk of accepting substandard containers is expressed frequently as the lot tolerance per cent defective (LTPD). The LTPD is that true per cent defective in the poor quality lot which will be accepted by the customer 10 per cent of the time; *e.g.*, if a property of an attribute acceptance sampling plan is a 6 per cent LTPD, approximately 10 out of 100 lots of containers shipped to the customer, in which the true per cent defective is 6 per cent, will be accepted—90 shipments will be rejected.

The quality control team, charged by management with the responsibility of protecting the production unit, is not justifying its existence by solely auditing ware to estimate the quality level after production is terminated. The effective quality control unit *must* communicate to production personnel how good or how poor the quality of ware is, while the containers are being produced, so that remedial action may be taken by production personnel before any sizable numbers of defectives are turned out.

First-hand experience repeatedly bears out that "hot end" operators generally are able to determine with artful accuracy the cause of any substandard production, if they are aware that such deficiencies exist. Particular consideration is given to finish defects and functional attributes: checks, splits, shoulder cuts, chips, cocked necks, twisted bottoms, seeds, heel taps, etc. A rapid replacement of the parison mold or the blow mold may correct the defective manufacture. A change in swabbing techniques may clear up the difficulty. Whatever adjustment in the cycle or in the I-S machine itself may be indicated, the operator cannot take action unless he is notified with good assurances that a deficiency exists. This is the primary responsibility and the most important function of quality control personnel.

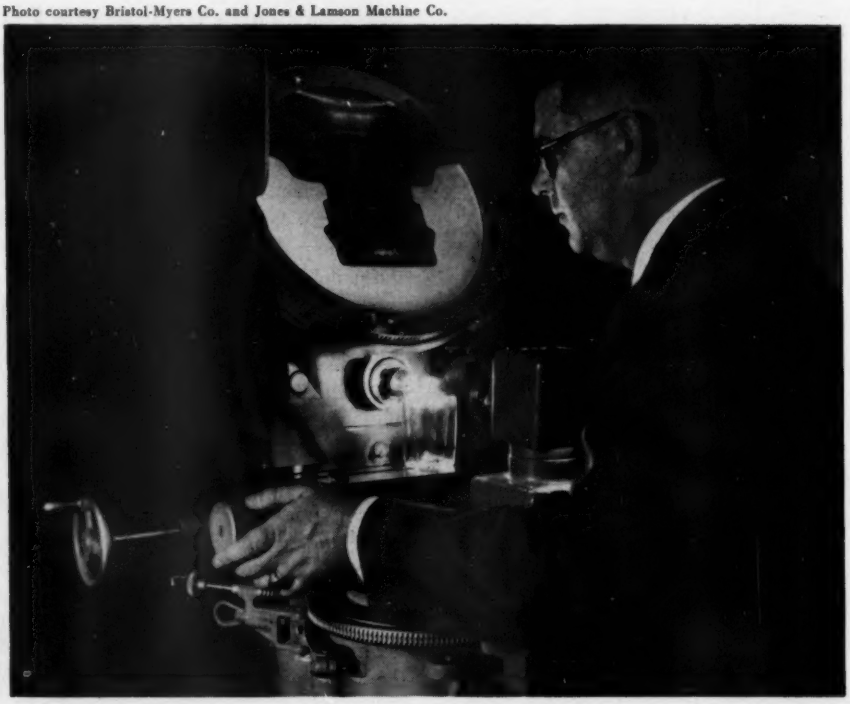
Any attempt to compensate for the production of ware which contains high percentages of finish defects, for example, by subsequent 100 per cent inspection (other than by mechanical means) is wasteful and certainly foolhardy. I have never witnessed or heard of any culling operation of this nature that was more than 38 per cent effective. High-quality glassware must be produced; it cannot be "inspected into" poor-quality ware.

The means to effectively control production has been successfully demonstrated by the sequential analysis of attributes. Using this tool, the quality control team can determine with set assurances whether defective ware found in a sample during production is occasional or chronic; whether it is the result of expected performance owing to limitations of the manufacturing process; or whether it is caused by the malfunction of the unit which requires immediate remedy.

A graphic set-up of such a sequential system will demonstrate its origin and application. The first step is to decide the assurances that are required to detect an

Use of the optical comparator is one effective means of commercial glass container inspection. Shown here is the enlarged and inverted image of a bottle neck. From this and other mechanical operations, the data necessary for analyzing defects in manufacture can be obtained.

Photo courtesy Bristol-Myers Co. and Jones & Lamson Machine Co.



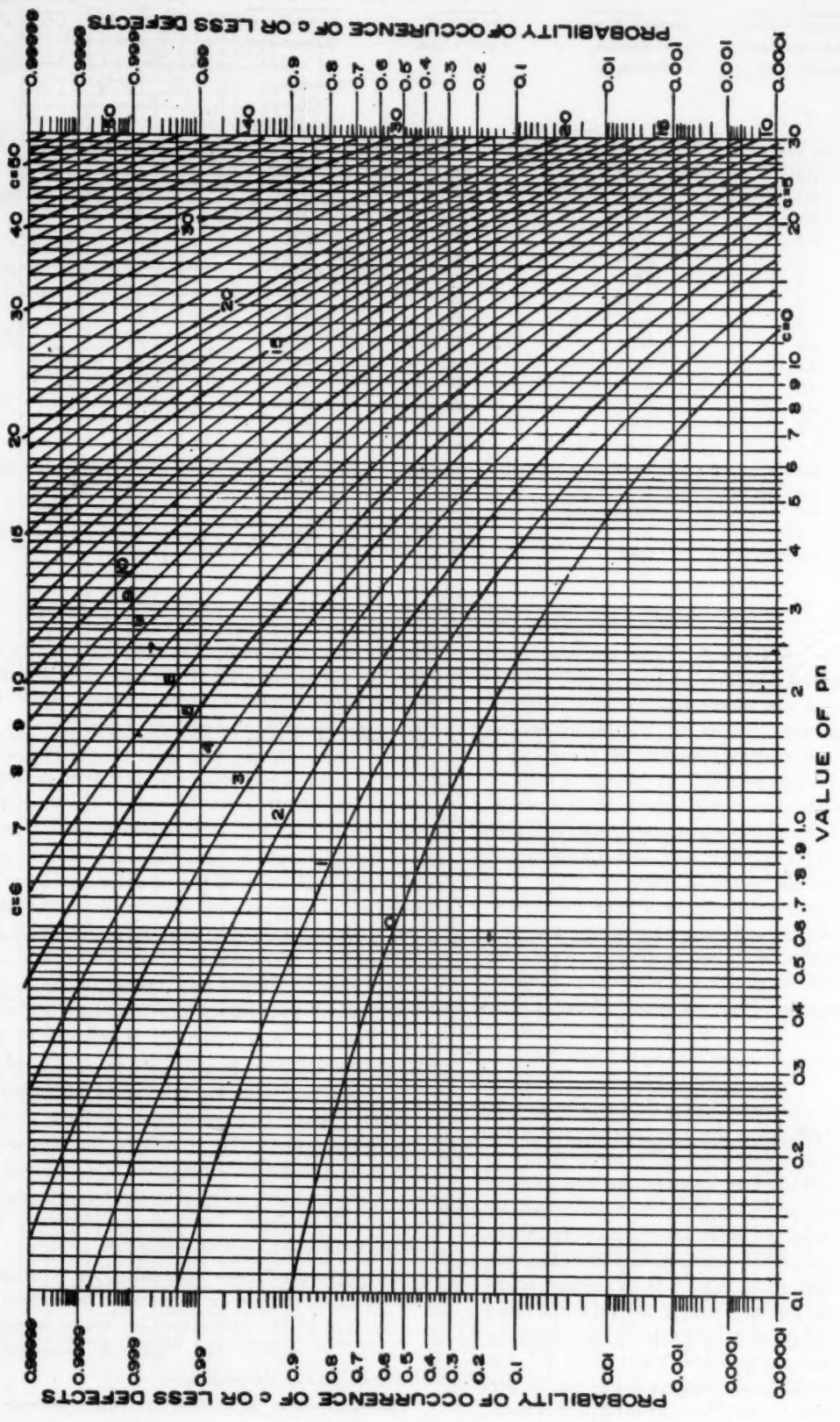


Fig. 1. Cumulative probability curves of the Poisson exponential distribution.*

*Reprinted with permission from H. F. Dodge and H. G. Romig, *Sampling Inspection Tables*, 1944, John Wiley & Sons, Inc.

1 Assumed Values of true Per Cent Defective (100p)	2 Assumed Values of Fraction Defective (p)	3 Product of p and n (pn)	4 Probability of Occurrence of 2 or Less Defectives in a 130-Piece Sample (P_a)	5 Probability of Acceptance (Per Cent = 100 by Column 4)
Per Cent				Per Cent
0.2	0.002	0.26	0.9998	99.98
0.4	0.004	0.52	0.998	99.8
0.6	0.006	0.78	0.991	99.1
0.8	0.008	1.04	0.97	97
1.0	0.010	1.30	0.96	96
1.5	0.015	1.95	0.87	87
2.0	0.020	2.60	0.73	73
2.5	0.025	3.25	0.59	59
3.0	0.030	3.90	0.46	46
3.5	0.035	4.55	0.34	34
4.0	0.040	5.20	0.24	24
4.5	0.045	5.85	0.18	18
5.0	0.050	6.50	0.12	12
5.5	0.055	7.15	0.07	7
6.0	0.060	7.80	0.05	5
6.5	0.065	8.45	0.03	3
7.0	0.070	9.10	0.02	2
7.5	0.075	9.75	0.015	1.5
8.0	0.080	10.40	0.003	0.3

TABLE I

out-of-control line performance. These are best illustrated by an operating characteristics curve (OC curve). The OC curve is a plot of the true per cent defective ware in a production segment vs. the probability of recognizing the substandard condition by examining a sample. As discussed previously, the OC curve may be defined by the customer or past experience by specifying the sample size n and the acceptance number c. It also may be defined by specifying AQL and LTPD which actually are two points on the OC curve.

Numerous OC curves already have been constructed for attribute sampling and inspection plans, and are available in published reference works.[1] A rapid and excellent means of constructing these curves employs a good approximation of obtaining the necessary correlation of variables, known as the cumulative probability curves of the Poisson exponential distribution[2] shown in Fig. 1.

One begins the construction of the OC curve by assuming a number of values for the true fraction p of a lot which is outside of specification or control. Unity 1 will represent a 100 per cent defective lot. The product of these fractions and the sample size n are values pn along the abscissa for the cumulative probability curves of the Poisson exponential distribution. Where the specified value of the parameter c acceptance number, intersects a vertical line passing through each abscissa value pn, a value for the fractional probability of acceptance P_a may be read on the ordinate. When $P_a = 0.5$ for example, the probability of acceptance will be 50 per cent. Several coordinates may be calculated in this manner by selecting different values of p.

As an example, consider the sampling and inspection plan that will accept a lot if no more than 3 defectives are found among 130 samples ($n = 130, c = 3$). Using Fig. 1, it is possible to construct Table I.

Using columns 5 and 3 in Table I, the OC curve in Fig. 2 is constructed. Note that the AQL is 1.05 per cent and the LTPD is 5.15 per cent. The next step in setting up line control is to translate these constants into a practical workable plan that will enable the quality control personnel to help the operator recognize a deficiency by examining ware emerging from the lehr.

The particular sequential analysis techniques that will be treated here were devised by the Statistical Research Group, Columbia University.[3] Owing to the fact that the derivations and applications were mainly the work of A. Wald, the plan commonly is referred to as the Wald sequential plan, and will be so designated here.

The Wald plan uses the criteria of producers' and consumers' risks to arrive at one of three decisions:

1. The preassigned risks of making an incorrect decision to accept the lot or segment of production have been satisfied to the extent that the lot or segment of production *is* accepted. The "hot end" operator *is not* directed to look for process difficulties.

2. The preassigned risks of making an incorrect decision to reject the lot or segment of production have been satisfied to the extent that the lot or segment of production *is* rejected. The "hot end" operator must find the cause for the deficiency.

3. The evidence is insufficient for either decision, and so more samples must be examined.

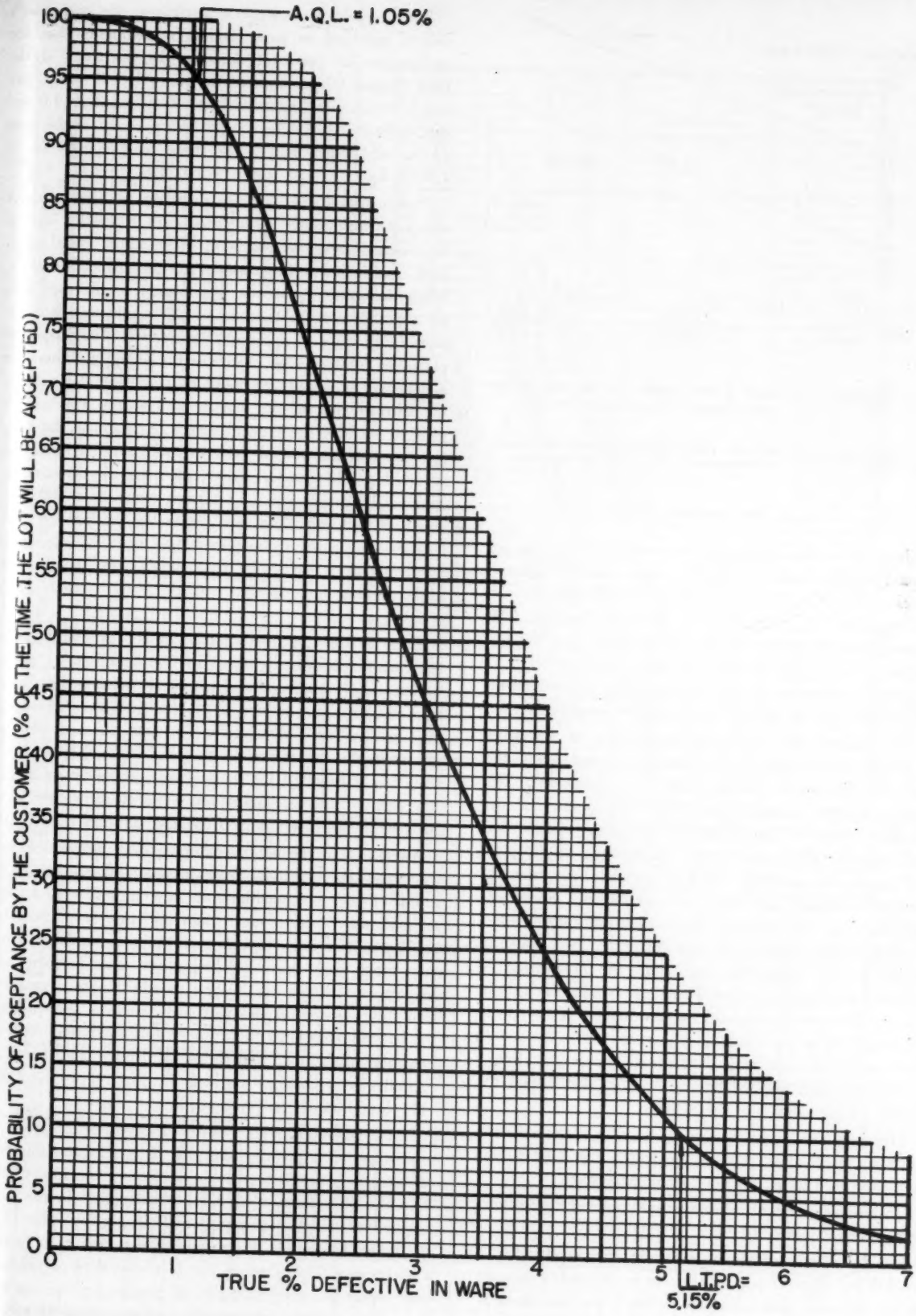
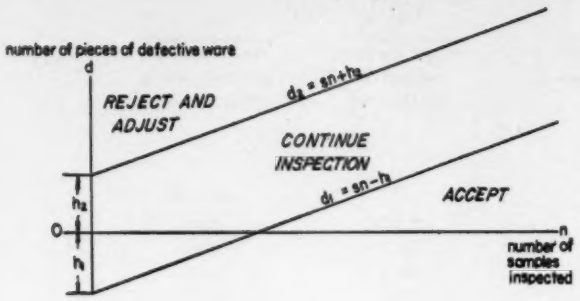


Fig. 2. Operating characteristic curve for the attribute acceptance plan in which n=130, c=3.



$$h_1 = \frac{0.9777}{\log\left(\frac{(1-p_1)p_2}{(1-p_2)p_1}\right)} \qquad h_2 = \frac{1.2553}{\log\left(\frac{(1-p_1)p_2}{(1-p_2)p_1}\right)} \qquad s = \frac{\log\left(\frac{1-p_1}{1-p_2}\right)}{\log\left(\frac{(1-p_2)p_1}{(1-p_1)p_2}\right)}$$

$p_1 = \frac{\%\ \text{AQL}}{100}$ which is that fraction lot defective desired to be accepted 95 per cent of the time.

$p_2 = \frac{\%\ \text{LTPD}}{100}$ which is that fraction lot defective desired to be accepted 10 per cent of the time.

Fig. 3. Wald sequential analysis.

Using this plan, high-quality production will be accepted rapidly and low-quality ware will be rejected quickly. More extensive sampling and inspection will be required of production of mediocre quality. The criteria for the three actions—*(1)* accept and do not adjust process, *(2)* reject and adjust process, or *(3)* continue examining samples—is described by two parallel straight lines on rectangular coordinate paper (Fig. 3).

The vertical axis represents the number of defectives found in the sample. The horizontal axis represents the number of samples which have been inspected. The quality control inspector plots the total number of defectives found in the sequential sampling against the total number of samples inspected. As long as the plotted points fall between the two parallel lines, the inspector continues drawing and examining additional samples from the process. Inspection terminates when a plotted point falls on or outside of the two lines. If it falls on or above the upper line, the production is rejected and process adjustments are made. If it falls on or below the lower line, the production is accepted. Of course, it is good control policy to watch the trend. Process adjustments may be made if successive plotted points approach the "rejection" area so that actual rejection of the ware may be avoided.

The formulae given in Fig. 3 describe a special case of Wald sequential analysis in which the LTPD and AQL are used to set up the control procedure.

To describe control by sequential analysis, the following example is cited.

The quality control inspector is furnished with a worksheet (Fig. 4, page 439). He is physically located in an enclosed area adjacent to the lehr. The room is set up with optimum conditions for inspecting glassware—work-space, light, etc.

With respect to functional attributes, the consumer's risk is specified to pass production segments that are as bad as 5.0 per cent defective 10 per cent of the time (Reject 90 per cent of the time: LTPD = 5.0 per cent). Production segments that are as good as 1.0 per cent defective should be accepted 95 per cent of the time (AQL = 1.0 per cent). For these requirements $h_1 = 1.3639$, $h_2 = 1.7510$, and $s = 0.02499$.

The inspector's worksheet is set up as illustrated. A sampler continuously withdraws ware from the line to represent the various molds in substantially equal numbers, and delivers the samples to the inspection area. While inspection proceeds, production is diverted into an area adjacent to the end of the production line reserved for ware of questionable quality. The inspector plots his results as he examines the samples. Whenever a defective is found, the mold number is noted next to the vertical rise on the plot as well as the appropriate code to identify the type of defect. As soon as the plotted points touch one of the two solid parallel lines, the diverted production is either accepted or rejected as directed by the sequential sampling chart. If a rejection has occurred, the "hot end" operator is directed that a process adjustment is required. The repetitive abnormal incidence of a particular type defect, peculiar to one mold number undoubtedly will aid him in making the correction.

Once a decision to accept or reject production has been made, the ware is moved to the appropriate "ship" or "reselect" area, and the inspector resumes his function while new production is diverted into the "questionable quality" area once again. The next series of plotted points begins by returning to the "starting line" . . . traveling parallel to the vertical axis from the point of intersection with the solid line. The starting line is a broken line with the slope s passing through the origin.

Variations of sequential sampling and inspection for attributes may include using separate charts for each mold of the I-S machine, or one inspector and one sampler may control more than one line at a time. In any case, it is important to separate the inspector from any other line function. Inspectors who perform an inspection function on the line in addition to a production duty (such as packing) are likely to subordinate the control aspects of their job to the point that control becomes ineffective. Separation of duties and keeping formal charts such as the one in Fig. 4 promote the vital function of quality control.

In conclusion, it is noteworthy to recognize the primary advantage of sequential analysis. Note that the number of samples required to reach a decision is decidedly less than the 130 pieces needed for examination in the corresponding single sampling and inspection plan for attributes. Of course, the sample size necessary to make a decision will vary according to the quality of production segments. For example, if production is actually 1 per cent defective, an average sample size of 81 pieces

(*Continued on page* 469)

IDENTIFICATION OF DEFECTS															
F-0	FINISH(	F-12	FINISH(	F-24	FINISH(		NECK	S-5	SHOULDER(		BOTTOM	G-3	GENERAL(
F-1	Chipped	F-13	Broken	F-25	Out of spec. T dimension	N-6	Slug	S-6	Stuck Bottle	B-2	Heavy	G-4	Brush oil or carbon specks
F-2	Split	F-14	Check	F-26	E	N-7	Hollow	S-7	Blister	B-3	Heel tap	G-5	Out of shape
F-3	Overpress flange	F-15	Rough	F-27	I	N-8	Dirty	S-8	Edge or side seam	B-4	Projection	G-6	Dim letters
F-4	Bulged	F-16	Dirty	F-28	H	N-9	Bent	S-9	Mold seam	B-5	Light	G-7	Wrinkles or laps
F-5	Unfilled (warped top)	F-17	Towed in	F-29	Broken sealing bead	N-10	Fins	S-10	Cut	B-6	Rocker	G-8	Wavy
F-6	Heavy shear marks	F-18	Set over	N-0	NECK(	N-11	Long	S-11	Blank seam	B-7	Plate check	G-9	Nicked or stuck plunger
F-7	Fin on top of finish	F-19	Out of round	N-1	Unfilled bead	S-0	SHLDR.	S-12	Sunken edge	B-8	Pin hole	G-10	Bird swing
F-8	Droplet under or top	F-20	Shifted	N-2	Checked bead	S-1	Thin	S-13	Tear or lap	B-9	Shifted	G-11	Panel Checks
F-9	Dropped Shoulders	F-21	Crushed under	N-3	Checked base	S-2	Sunken	S-14	Thin	B-0	GENERAL	G-12	Broken ware
F-10	Bent or Crooked	F-22	Baffle marks	N-4	Tear in base	S-3	Fins	B-0	BOTTON(	G-1	Stones	G-13	Washboard
F-11	Soft blisters	F-23	Seeds	N-5	Choked	S-4	Checks	B-1	Flanged	G-2	Seeds	G-14	Uneven distribution

SHAMPOO BOTTLE — DESCRIPTION OF WARE

8-OUNCE — SIZE; 16-R-7955 — PART NO.

14 — LOT NO.; WR-0445 — PRODUCTION ORDER

FEB. 28 19 61 — DATE; 4 — LINE; 3 — SHIFT

HAIR PRODUCTS, INC. — CUSTOMER

A. KNOX — SUPERVISOR

L. SMITH — INSPECTOR

1% — A.Q.L.; 5% — L.T.P.D.

1.364 h_1; 1.751 h_2; 0.025 s

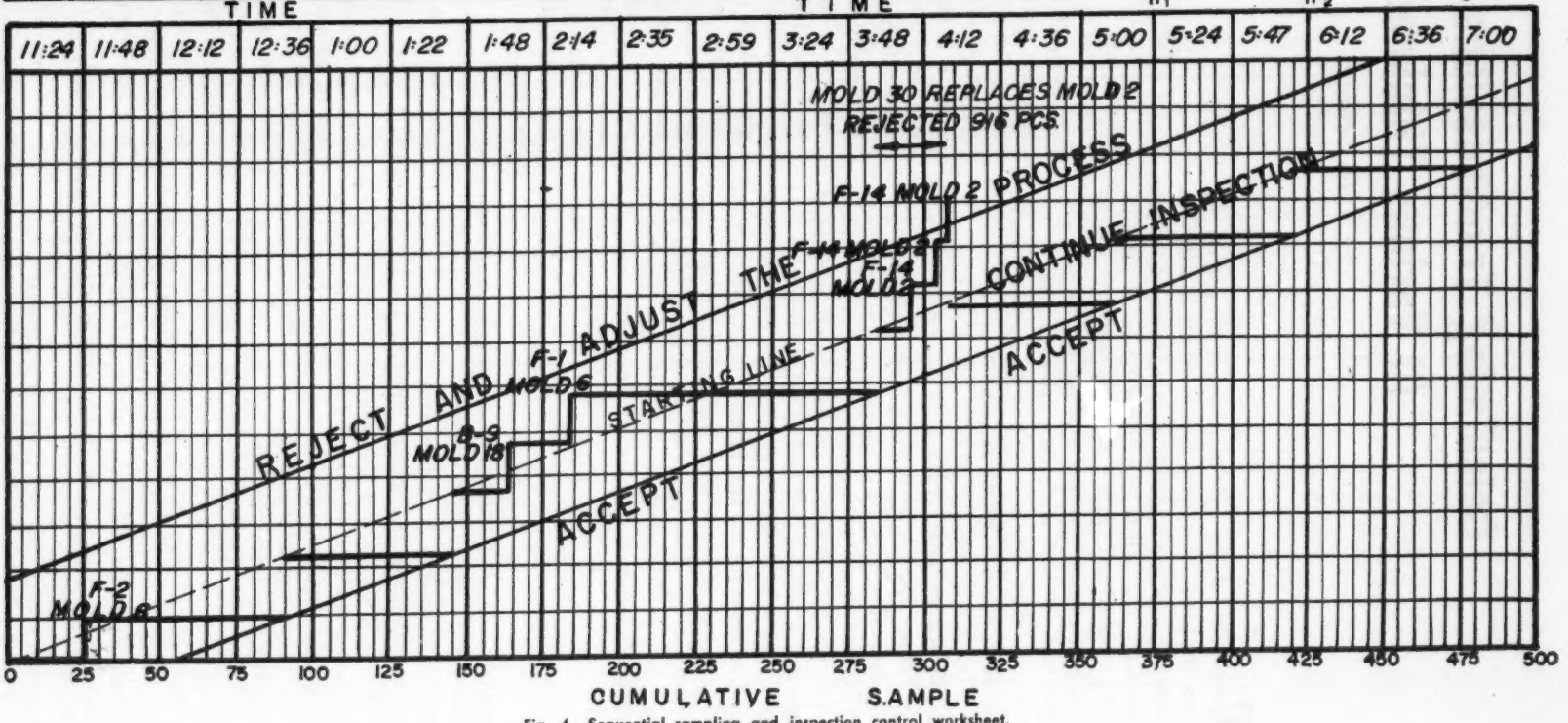


Fig. 4. Sequential sampling and inspection control worksheet.

Calculating Transmissions of Glasses At Various Thicknesses

by S. R. Scholes

Calculation of the light-transmission of a glass for some thickness other than that at which it has been spectrophotometrically measured is a somewhat tedious operation. This article sets forth a review of the principles involved and offers a diagram, related to a slide-rule, which enables its user to make the estimate with speed and with sufficiently close approximation.

At the outset, certain terms and symbols used in the discussion must be defined, as follows:

The loss by reflection at each surface = r
Reflectance factor = R
Transmittance between surfaces = Te
Transmission = Tn
Optical density = D

The loss by reflection is the fraction of the incident light that is reflected back and so fails to pass each surface of the pane or slab of glass. At the first surface, r is a fraction of the incident light; at the second, or outgoing surface, it is the same fraction of the light that reaches the second surface, after the first reflection loss and whatever absorption the glass possesses. The reflection loss is related to index of refraction, n:

$$r = \left(\frac{n-1}{n+1} \right)^2$$

This relationship holds only for normal incidence, where the entering beam of light strikes the glass perpendicularly to its surface. Also, it is assumed that the glass specimen has clean and polished surfaces. The value of the index, n, depends not only upon the composition of the glass, but also upon the color band (wave length) of the light employed.

The reflectance factor is that fraction of the intensity remaining after a reflection loss:

$$R = 1 - r$$

The factor is written as a decimal, taking the intensity of the incident light as unity, 1.00. Generally, it is assumed that 1.5 can be taken as the index of refraction of glass, giving for r the value 0.040, and for R, 0.96. Two reflectance factors must be applied, the product of which is R^2; this is commonly taken at 0.92, and no great error results. However, it may be of interest to look at values of r, R, and R^2 (Table I) for different indexes of refraction.

TABLE I

n	r	R	R^2
1.50	0.0400	0.9600	0.9216
1.53	0.0439	0.9561	0.9104
1.56	0.0479	0.9521	0.9050
1.60	0.0523	0.9477	0.8980

The significance of the numbers in the R^2 column is that they represent the maximum transmissions of clean and polished specimens of glass, having the indexes quoted. The index, n, is usually measured in yellow light; it is higher for shorter wave lengths, as of blue or violet, so that smaller fractions of light of those colors can get through. To be sure, glass can be coated with extremely thin films of low-index material, and thereby reflectance is largely eliminated. That valuable contribution to photography is outside the scope of this discussion.

Transmittance, Te, is of greatest importance in colored glasses. In a perfectly colorless and clear glass, Te has unit value, 1.00—leaving out of consideration ultraviolet and infrared radiation, and dealing only with visible light. Selective absorption reduces transmittances differently for different color bands (wave lengths), and one sees that color for which the glass has the maximum transmittance. Here, it must be remarked that yellow and amber glasses actually have highest transmittance for red; but human eyes have more keenness ("visual acuity") for yellow, and see it; although the redness does become apparent in thick specimens. Also, a purple glass shows maxima of transmittance in both violet and red, and the eye does its own blending.

Te must be handled as the decimal fraction of the light received through the first surface that passes to the second surface. It is what remains after selective absorption. Te is often measured, directly, by spectrophotometer, when a colorless pane or slab is used to establish the 100 per cent (1.00) reference value; the effect of reflection is thus eliminated. Transmission is the term to be preferred for the fraction of the incident light that passes completely through the glass. It is made up of two reflectance factors and the transmittance factor:

$$Tn = R^2Te$$

and

$$Te = Tn/R^2.$$

That multiplication of factors has its analogy in commercial discounts. When successive discounts are quoted,

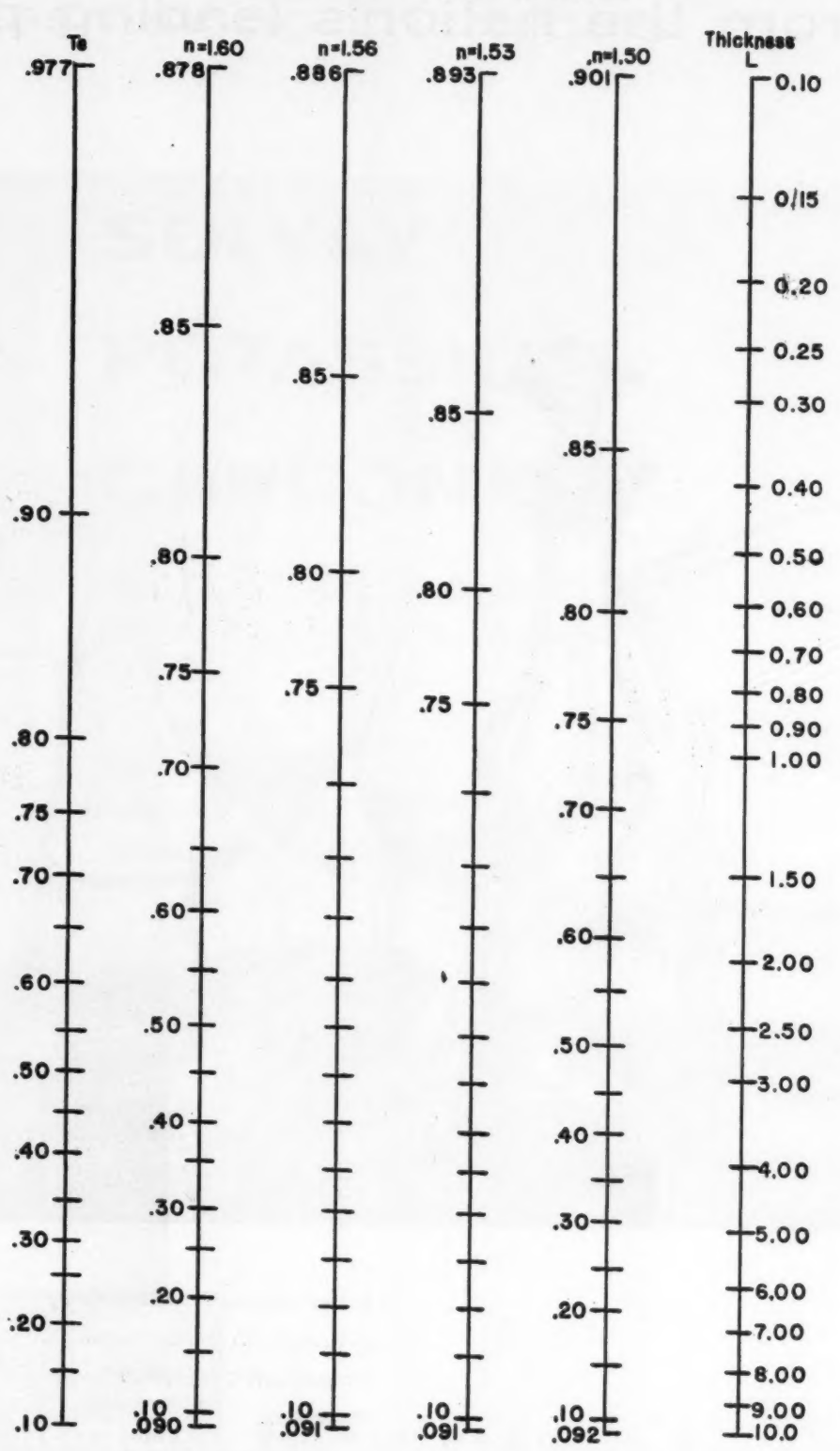


FIG. 1

"Slide-Rule" Diagram for Calculating Transmission vs. Thickness

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Convenient... easy-to-handle... clean... Solvay® Potassium Carbonate is produced to meet the rigid requirements of the glass industry. This highly soluble fluxing agent contributes luster, clarity, "ring" to quality glassware and helps regulate certain physical and electrical properties of special purpose glass.

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one does not find the final price by adding discounts, but but multiplying together the per cents remaining after subtracting each discount (as a decimal) from 1.00.

Optical density, D, is a useful concept. Numerically, it is the $\log_{10}$ of the reciprocal of transmittance, which is, of course, minus log Te. Optical density is a measure of the light-stopping power of a glass. It is directly proportional to thickness. It is also directly proportional to the concentration of colorant.

At this point, the reader will be justified in remarking that reflectance adds to the light-stopping of a slab or plate of glass, so that the actual, overall optical density is greater than D. That is true. But reflectance factors are constants independent on thickness, and large errors would result, if calculations were based on a concept of optical density referred to overall transmission.

The change of transmittance with thickness is exponential in character, according to the Beer-Lambert Law. If L is a subscript denoting thickness, and x and y are numbers representing units of thickness, we have:

$$Te_{L=x} = Te^{x}_{L=1}; \text{ and } Te_{L=y} = Te^{y}_{L=1} \quad (1)$$

$$\text{Also, } \log Te_{L=x} = x \log Te_{L=1} \quad (2)$$

$$\text{and } \log Te_{L=y} = y \log Te_{L=1} \quad (3)$$

Dividing (2) by (3) and changing signs:

$$\frac{-\log Te_{L=x}}{-\log Te_{L=y}} = \frac{x}{y} = \frac{D_{L=x}}{D_{L=y}} \quad (4)$$

D is a positive number, being the logarithm of 1/Te, which is greater than unity. Therefore, D has a real logarithm, which becomes useful. From (4):

$$\log D_{L=x} - \log D_{L=y} = \log x - \log y \quad (5)$$

Equation (5) presents the basis for a mechanical type of calculation, slide-rule style, which will quickly estimate transmissions at different thicknesses. The essential diagram for this purpose is illustrated in Fig. 1. This diagram is laid off in vertical lines, as follows:

The line at the right, headed "L" (or "C"), is divided according to the logarithms of numbers denoting thickness. The four columns under "Tn", for designated values of n, are laid off in lengths on the same scale as the L line; the lengths correspond to the values of log D which identify the respective transmissions.

For readers familiar with logarithms, it is not necessary to say that the values of log D have been converted into entirely negative numbers—D itself being less than 1 for Te values over 0.100. For example (Table II), when Te = 0.977, its $\log_{10}$ is $\bar{1}.9900 = -0.01$, D = 0.01, and log D = $\bar{2}.00 = -2.00$. Also, for another example, when Tn is 0.550 (and n is 1.50), Te = 0.597, log Te is $\bar{1}.7758 = -0.2242$, and D is 0.2242. Log D becomes $\bar{1}.3506 = -0.6494$, of which number only –0.65 is significant for plotting. Similar treatment has been given to the logarithms of numbers between 0.1 and 1.0 in the L column.

A degree of "hair-splitting" is involved in the inclusion of columns of Tn for several indexes of refraction. The extra columns merely show that higher indexes have a real effect at high transmittances, but a negligible effect at lower transmittances.

Finally, the column at the far left-hand, headed Te, is provided for estimating the change of transmittance with thickness or with concentration of colorant, "C". This last column is also laid off in units corresponding to log D.

In using the diagram, one measures on the L line, with dividers or scale, a length representing the difference between the two thicknesses involved, old and new, and lays off this length from a point on the Tn line opposite the measured transmission, thus arriving at the transmission at the new thickness. He measures up or down, of course, depending upon the proposed change in thickness *i.e.*, less or more. The reader will observe that the procedure is simply operating according to equation (5).

Because optical density is directly proportional to concentration of colorant, it is obvious that the L line can represent concentrations and can be applied to the Te line to estimate transmittances at various concentrations. Concentration may be expressed in any units—ounces per ton as well as grams per cubic centimeter. It will occur to chemists making analyses by comparative transmittances of colored solutions that the diagram will make rapid estimation possible.

To readers already familiar with the interesting and important subject of transmission and transmittance, this paper will seem unnecessarily long and wordy. Others may welcome the attempt to clarify the mathematics of the subject, as well as to present a simple method for rapid calculation.

In conclusion, the writer expresses his thanks to Professor C. H. Greene and Professor L. C. Butler, for valued comments and criticisms. The diagram was drawn by Professor Gerald F. Burdick.

TABLE II

Tabulation of Numbers Used in Constructing Diagram

Te	Log D	Tn (n = 1.50)	Te (Tn/R²)	D (–log Te)	Log D
0.977	–2.00	0.901	0.977	0.0100	–2.00
0.950	–1.65	0.850	0.922	0.0352	–1.45
0.900	–1.34	0.800	0.868	0.0515	–1.21
0.850	–1.16	0.750	0.814	0.0895	–1.05
0.800	–1.01	0.700	0.760	0.1195	–0.92
0.750	–0.90	0.650	0.705	0.1517	–0.82
0.700	–0.81	0.600	0.651	0.1864	–0.73
0.650	–0.73	0.550	0.597	0.2242	–0.65
0.600	–0.65	0.500	0.542	0.2656	–0.57
0.550	–0.58	0.450	0.488	0.3164	–0.50
0.500	–0.52	0.400	0.434	0.3625	–0.44
0.450	–0.46	0.350	0.380	0.4202	–0.38
0.400	–0.40	0.300	0.326	0.4875	–0.31
0.350	–0.34	0.250	0.271	0.5667	–0.24
0.300	–0.28	0.200	0.217	0.6636	–0.18
0.250	–0.33	0.150	0.163	0.7885	–0.10
0.200	–0.16	0.100	0.109	0.9646	–0.01
0.150	–0.08				
0.100	0.00				

ACS
Glass Division Papers

Second of two reports covering papers delivered at the Society's 63rd Annual Meeting.

Session III, Kinetics of Nucleation and Crystallization—Guy E. Rindone, Pennsylvania State University, Chairman

Kinetic and Molecular Constitutive Criteria for Glass Formation. By D. Turnbull, General Electric Research Lab. According to recently developed models for glass transition, all liquids of whatever constitution would form glasses, when sufficiently undercooled, save for the intervention of crystallization. Whether or not a glass actually forms is then determined by the cooling rate and the magnitude of the crystallization kinetic constants. In this paper a general criterion was proposed for glass forming tendency on the basis of which molecular constitutive effects may be interpreted. The criterion encompassed Zachariasen's crystal chemical criterion and seemed to lead to satisfactory explanations for the effects of impurities and molecular asymmetrization on glass forming tendency.

Nucleation Catalysis in Glasses. By W. D. Hillig, General Electric Research Lab. The fundamental significance of the term "nucleation catalysis" was examined to determine whether such a factor was essential to the uniform precipitation processes leading to the formation of glass-ceramics. The classical nucleation theory was briefly reviewed to provide the background for this discussion, with special emphasis upon heterogeneous nucleation catalysis and the transient time for attaining steady-state nucleation.

The experimentally observed nucleation kinetics in a limited series of BaO-Al_2O_3-SiO_2-TiO_2 revealed no anomalous behavior that could not be interpreted in terms of a simple nucleation process, if the change of surface free energy with composition was considered. The variety of factors that influence especially the surface free energy, which in turn controls the nucleation kinetics, was discussed. These factors included adsorption and varying degrees of surface diffuseness, as well as relaxation of the coordination shells and the electronic structures of atoms of the interface. It was concluded that nucleation catalysis is too broad a term and is not necessarily essential to uniform devitrification.

Kinetics of Nucleation and Crystallization Processes in Sodium Phosphate Glasses: Part I, Nucleation and Crystallization of Sodium Trimetaphosphate Glass. By A. E. R. Westman and M. Krishna Murthy, Ontario Research Foundation. Presented by Murthy. Until now the study of nucleation and crystallization in glass has been restricted to physical methods because the glasses of commercial interest are insoluble in water and any process used to get them into solution invariably destroys their structure and constitution.

In this investigation, paper chromatographic methods were used for the first time to study the mechanism of nucleation and the kinetics of crystallization of water soluble sodium trimetaphosphate glass. Data were presented on the kinetics of the processes and the theoretical significance of the results was discussed. The following conclusions were given.

1. The crystallization of sodium trimetaphosphate glass in the temperature range 300°C to 350°C consists of two steps: nucleation and crystallization.
2. The nucleation period is very small at 350°C—about 7 minutes—and increases with decrease in temperature to about 4 hours at 300°C. The activation energy of nucleation is found to be 50.5 kcal per mole.
3. The crystallization process in the temperature range 308°C to 350°C is very rapid and is complete within a short period. The activation energy of crystallization in this temperature range is 20.1 kcal per mole.
4. The kinetics of crystallization at 300°C is quite different. There is a break in the Arrhenius plot for crystallization between 308°C and 300°C. This has been interpreted as due to a change in the polymorphic modification of sodium trimetaphosphate crystals.
5. Since the activation energy of nucleation is about twice the activation energy of crystallization, the transformation process is affected by any factor which influences the formation of nuclei.

Devitrification Kinetics of Fused Silica. By N. G. Ainslie, C. R. Morelock, and D. Turnbull, General Electric Research Lab. Presented by Ainslie, now at IBM Research Lab. Nearly all substances are more stable in their crystalline than in their glass state. Nevertheless, glasses, once formed, crystallize ("devitrify") only very slowly

even at elevated temperatures. Like liquids they crystallize by a process of nucleation and growth.

In most glasses the rate of homogeneous crystal nucleation (*i.e.*, nucleation unassisted by foreign surfaces) is too small to be measurable, and nucleation occurs, if at all, heterogeneously on foreign particles in the glass or on its surface.

The factors that influence the high temperature kinetics of nucleation and growth of cristobalite in fused silica were investigated, and the following conclusions drawn.

1. Cristobalite nucleation on the external surfaces of fused silica is catalyzed by superficial condensed phase impurities.
2. Because most fused silica objects have enough "dirt" on their surfaces to catalyze nucleation uniformily, the rate of devitrification as it is ordinarily seen is controlled, not by the nucleation rate, but by the rate at which the cristobalite grows into the glass.
3. The rate of cristobalite growth is markedly accentuated by the presence of impurities. Oxygen and/or water vapor contained in the gas phase, by diffusing through the thickening layer of cristobalite to the crystal-glass interface, are able to catalyze the growth process.
4. The thickness of the cristobalite layer that grows from the external surfaces of fused silica objects that are fired in air, oxygen, or water vapor, vary linearly as the square root of time, suggesting a diffusion controlled process.
5. The cristobalite growth rate is decreased sharply by reducing the oxygen or water vapor content of the gas phase using a suitably strong oxygen getter such as chromium, silicon, selenium, or graphite.
6. The observed growth rates in the presence of the catalyzing gases, oxygen or water vapor, are hundreds of times greater than the growth rate calculated from the formula

$$u = \frac{\triangle h(T_m - T)}{3 \pi a^2 \eta T_m}$$

7. Cristobalite nucleation in the interior of fused silica is a relatively rare occurrence. The factors controlling this internal nucleation, and the subsequent growth, are not understood at present.

Nucleation and Crystal Growth Studies of Glass Melts. By Francis C. Lin, Westinghouse Electric Corp. The fundamental treatment of crystal growth was divided into two inter-related problems: *(1)* the initiation of crystallization, and *(2)* the growth of crystals. This paper reviewed the theory of Ostwald concerning nuclei formation, the classical theory of crystal growth developed by Volmer, Stranski, Becker, and Doring, and further expanded by Frank, Gibbs, and Canrera, as well as the early works of Tammann. The following is a summary of the results.

The formation of a new phase from a mother phase involves two interrelated processes: formation of nuclei, and the growth of these critical nuclei to macroscopic dimensions. The presence of foreign particles, the fluctuation in temperature, pressure, composition, and molecular arrangement in a glass melt are the factors that are responsible for nucleation. The nucleation rate increases with supercooling until a maximum is reached, and then decreases with further supercooling as diffusion becomes the controlling factor.

The nucleus growth rate increases with temperature and with time. Supercooling has an effect on the growth rate similar to its effect on the nucleus formation. At the same degree of supercooling different faces of a crystal nuclei grow at different rates, and irregular surfaces grow more rapidly.

Nucleating agents most frequently serve as catalysts and closely resemble the melt in atomic arrangement and relative spacings. The nuclei from the glass melt do not appear to have defined structure.

The experimental data fit well to the linear rate zero order equation as well as to the general rate constant expression for the activated process. However, the activation energy for nucleus growth obtained was much lower than that for viscous flow of the glass. It is felt that in the early stage of the growth the short-range rearrangement required in the glass is much more a controlling factor than the rate of mass diffusion.

Partial Structure of Glass and the Reconstructive Nature of Devitrification Processes. By S. D. Brown and R. Ginell, University of Utah. Presented by Brown. In view of recent work on the structure of liquids, it appeared statistically improbable that homogeneous nucleation would occur in real glasses. It was shown that heterogeneous nucleation and crystal growth are reconstructive in nature. It was further hypothesized that growth of a crystal phase in a glass proceeds via some sequence of rate processes. For this process an equation was derived. Furthermore, because it appeared that Tait's Law was obeyed by liquids, the Tait's Law behavior of several glasses was examined.

Diffusion of Gold in Glass. By R. H. Doremus, General Electric Research Lab. In this paper experiments were carried out in which the rate of growth of gold particles was measured and used to calculate the diffusion coefficient of gold in the glass. The particles were nucleated by irradiating the glass which contained cerium as a nucleating agent.

Diffusion coefficients of gold in a sodium silicate glass were measured from rates of precipitation of the gold in the glass. These rates were followed with the optical absorption of the glass, from which the total volume of precipitated gold was calculated. It was shown that the gold diffused as atoms under the conditions of these experiments. The number of gold particles was constant throughout precipitation; nucleation of the particles was effected by irradiation of the glass, which contained cerium as a nucleation agent sensitive to radiation. The activation energy for diffusion was measured by starting the precipitation at one temperature and completing it at another. Between 400°C and 530°C the activation energy was 56.3 kcal/mole, whereas it was 39 kcal/mole between 530°C and 630°C. Annealing the glass did not affect these activation energies. The diffusion coefficients of gold were compared with those of other substances

in similar glasses, and it was shown that the diffusion of the gold was not related to the viscosity of the glass.

The joint symposium on "Nucleation and Crystallization in Glasses and Melts" was concluded with a summary given by Howard R. Swift, Libbey-Owens-Ford Glass Co.

Presented concurrently with the last session of the joint symposium was the first session of the general technical papers.

Session I—Harold E. Simpson, Alfred University, Chairman

Theoretical Analysis of Convection Currents in Glass Tanks. By Alve J. Erickson, Massachusetts Institute of Technology. The Navier-Stokes equations were specialized for analysis of the flow caused by density gradients in a vertical cross-section of a glass tank. The resulting equations were solved approximately, thus determining the streamline pattern and velocities.

Fundamentals of Glass Transmission Measurements. By H. A. Kerry, American Potash and Chemical Corp. Because light transmission measurements are necessary to control glass color, this paper reviewed the fundamentals of light transmission and transmission measurements. Included were discussions on the radiant energy transmitted by glass, light sources, and instrumentation used. Typical spectra of colored glasses were shown and the correlation with color discussed. Emphasis was placed on the manipulations involved in the measurements and the interpretation of the spectra.

Stresses Introduced into Glass by Replacing Alkali Ions Near the Surface by Other Alkali Ions from a Melt. By S. S. Kistler, University of Utah. The replacement of alkali ions in the surface of glass when exposed to a molten salt of another alkali was studied at different temperatures and times. When this replacement was confined to one surface of an optically flat glass disc, the progress of the replacement could be followed by the distortion of the disc owing to compressive or tensile stresses set up in its surface. Replacement of small ions by larger ones produced compressive stress, while small ions replacing larger ones caused tension. The distortion of the discs was conveniently followed by the development of Newton's rings between disc and an optical flat.

Maximum stress observed was 120,000 psi, and activation energies were measured. When sodium ions were replaced by potassium ions, as little as 0.02 micrograms of potassium per square centimeter were detected in glass discs 0.1 mm thick.

A Method for Investigating the Mechanical Properties of Glass Fibers Under Torsional Load. By John F. Mooney and Edward T. Weber, III, Rutgers University. Presented by Weber. An apparatus was described in which a glass fiber was subjected to a twist by the application of a dc current to a pair of Helmholtz coils surrounding a small permanent magnet hanging from the fiber. A float arrangement may be adjusted to maintain the tension in the fiber low enough to prevent elongation. The apparatus is capable of measuring flow or delayed elastic effect at temperatures lower than those usually reported in studies of these phenomena.

High Temperature Viscosity Determinations of Boron Oxide and Binary Alkaline Earth and Alkali Borates, with Special Emphasis on Rubidium and Cesium Borates. By Pei-Ching Li, Anil C. Ghose, and Gouq-Jen Su, University of Rochester. Presented by Ghose. It was pointed out that the viscosity-composition isotherms of rubidium and cesium borates have been found to follow the same trend as other alkali borates. For boron oxide between temperatures 500°C and 775°C the activation energy for viscous flow was found to be

$$E_{vis} = (4.213 \times 10^4)\ (1/T) - 22.15$$

and for temperatures above 775°C

$$E_{vis} = (1.121 \times 10^4)\ (1/T) + 7.40$$

in which T is in degrees Kelvin. The activation energies for viscous flow, E_{vis}, in kcal per gm mole were found to increase with all molten alkali borates in the order of Li > Na > K > Rb > Cs up to about 25 to 30 mole per cent of alkali oxide, and then to decrease with further addition of alkali oxides.

Fractography of Glasses Evidencing Liquid-in-Liquid Colloidal Immiscibility. By Stanley M. Ohlberg, Helen R. Golob, and Charles M. Hollabaugh. Glass Research Center, Pittsburg Plate Glass Co. Presented by Miss Golob. Glasses which become cloudy or opaque as a result of a finely dispersed liquid-in-liquid separation were advantageously studied by electron microscope examination of the fracture surface. In a SiO_2-TiO_2-CaO-Li_2O composition, the expected spheres and cavities each had a double tail. Disc-like structures were also observed on this sample. However, in a SiO_2-B_2O_3-Li_2O system, the expected spheres and cavities did not appear; instead, only shallow cavities, each having a single tail, were present.

Session II—J. R. Hensler, Bausch and Lomb Optical Co., Chairman

Influence of TiO_2 on the Dielectric and Other Properties of Transparent Glasses in the System SiO_2-K_2O-PbO-TiO_2. Presented by B. V. J. Rao, International Resistance Co. Glasses with progressive weight percent substitution of TiO_2 in the system SiO_2-K_2O-PbO were prepared and their properties determined. The results indicated that the dielectric constant increased progressively with increasing TiO_2 concentration. Values of dissipation factor indicated definite overall decrease with increasing TiO_2 concentration, when measured at 1 mc and 25°C, though the span between individual readings was wide. Increasing frequency in the range 550 kc was found to increase the DF values.

Density and refractive index curves indicated progressive increase with increasing TiO_2 concentration. Chemical durability, coefficient of thermal expansion, and softening temperature curves indicated definite transi-

tions. The anomalous behavior of TiO_2 in the system was presented.

High Temperature Density Determination of Boron Oxide and Binary Rubidium and Cesium Borates. By Pei-Ching Li, Anil C. Ghose, and Gouq-Jen Su, University of Rochester. Presented Mr. Ghose. Density determinations of pure B_2O_3 and binary rubidium and cesium borates were made in the temperature ranges 450°C to 1300°C and 500°C to 1100°C., respectively. With lower percentage of alkali oxide, the densities of all molten borates were found to be linearly related with reciprocal absolute temperature, while with higher percentage a direct dependence on absolute temperature was observed.

The rate of volume expansion, dV/dT, in the alkali borate systems increased with an increase of alkali oxide when the latter concentration was above 15 mole per cent. This increase in the rate of volume expansion followed the order Cs > Rb > K > Na > Li.

In the range of 15 to 20 mole per cent of alkali oxide, there was observed a sudden break in the rate of volume expansion. This suggested a possible sharp change in structural configuration of the alkali borates.

Oxygen Diffusion in Vitreous Silica. By Eugene W. Sucov, Glass Research Center, Pittsburgh Plate Glass Co. The diffusivity of oxygen ion in pure vitreous silica was directly determined by exchange measurements employing the stable isotope 0^{18} and mass spectrometer analysis. Results were compared with diffusivities derived from conductivity measurements on silica and with measurements of oxygen diffusion in silicate materials.

Nuclear Magnetic Resonance Studies of Glass Structure. By Philip J. Bray, Brown University. The nuclear magnetic resonance (NMR) spectra of Li^7, Be^9, B^{11}, Na^{23}, and Al^{27} were investigated in various glasses. All these nuclei possessed electrical quadrupole moments which interacted with electric field gradients present at the nuclear sites, giving rise to perturbations of the nuclear Zeeman levels. Consequently, the NMR line shapes were characteristically split or broadened in ways which provided information on the chemical bonding and local environment of the atoms.

Studies of B^{11} in glassy boron oxide, alkali-borate glasses, and other boron-containing compositions confirmed the planar triangular BO_3 unit in boron oxide and the change to tetrahedral BO_4 units as metal oxides were added. Lead borate glasses exhibited a reversal of this process in the region of high PbO content. The NMR spectra of Li^7, Na^{23}, and Al^{27} suggested some ordering around the metal ion positions.

Session III—Charles L. McKinnis, Owens-Corning Fiberglas Corp., Chairman

Gamma Irradiation Studies of Some Phosphate Glasses. By Adli Bishay, Argonne National Lab. The author discussed the change in gamma induced optical absorption in phosphate glasses resulting from changes in composition, conditions during melting, and additions of small amounts of some oxides. The induced absorption appeared to be due to the superposition of a number of individual absorption bands. In order to study some of the properties of these bands, a resolution of the observed absorption spectra into individual bands was conducted, based upon the assumption that each band is Gaussian shaped.

The increase in the total number of network modifying ions (per 100 network forming units) resulted in an increase in induced absorption. The effect of nonbridging oxygens in the structure and the polarizing power of network modifying ions was considered.

The gamma induced absorption of some phosphate glasses melted under reducing conditions was compared to that of glasses of the same composition melted under oxidizing conditions.

The effect of addition of small amounts of Fe_2O_3, Nb_2O_5, TiO_2, GeO_2, Ti_2O, As_2O_3 and some rare earth oxides was also discussed.

Apparatus to Study the Anelastic Behavior of Glasses. By Frank J. Matusik, Rutgers University. An apparatus was developed to study anelastic behavior of glasses at audio frequencies. Fine control of the applied frequency was achieved by introducing two decade resistance boxes into the parallel T feedback network of the audio signal generator. The sharp resonant peaks of materials such as vitreous silica were easily plotted. Data were also shown for some simple glasses.

Internal Friction and Viscous Flow in Glasses. By Harold T. Smyth, Rutgers University. In the development of a theory of viscous flow of simple glasses a simple model was postulated in which the flow occurred around either an unsaturated silicon or a nonbridging oxygen. It was shown that for flow to occur there must be a continuous creation and destruction of one or other of these defects. Further analysis showed that the application of a load developed at least two delayed elastic effects as well as the steady flow. The shorter of the two relaxation times was tentatively identified as being associated with the low-temperature internal friction peak in simple alkali silicate glasses and the longer one with the delayed elastic effect reported by Taylor, McNamara, Sherman, and others.

Compatibility of Hydrated Sodium Metasilicate Glasses with Inorganic and Organic Compounds. By Edward F. Bertaut, The Pennsylvania State University. By dehydration of $Na_2SiO_3.9H_2O$ at ordinary pressure, a series of glasses of approximate concentration $Na_2Si(OH)_6$ was obtained. Melting between room temperature and 100°C, these glasses presented a means of introducing thermally unstable compounds into a silicate glass without serious decomposition of the unstable materials.

The silicate glass itself was apparently analogous to fluorosilicate inasmuch as it contained Si^{+4} in 6-fold

(*Continued on page* 470)

Bibliography on Glass Structure*

PART XIII

330. W. Vogel

"Crystallizations in Phosphate Glasses and Their Structure," Silikattech., 6, 510-17 (1955); C. A. 50: 4471b.

Substantiates the views of Kordes (CA 47, 10945e) but suggests presence of PO_4 tetrahedra in HPO_3 and industrial glasses. Discusses effect of replacing Al_2O_3 by ZnO especially in relation to devitrification resistance.

331. O. L. Anderson

"Effect of Pressure on Glass Structure," J. Appl. Phys., 27, 943-9 (1956); Ceram. Abstr. 1957: 6c.

Pressure changes the average bond length and therefore the density of the glass. Two types of volume flow are observed namely densification which is reversible, and compaction which is not. The experiments show that the kinetics of densification agree qualitatively with theory.

332. P. L. Baynton and H. Moore

"Colors Produced in Glasses by Exposure to Radiations," J. Soc. Glass Technol., 40, 187-251T (1956); C. A. 51: 10021d.

Radiation color changes in Fe or Mn bearing glasses probably due to (1) valency changes in multivalent ions (2) displacement of electrons into anion vacancies. Studied combined and separate effects of As, Ti and Ce on development of iron colors in soda-lime-silica glasses. The fading of radiation-induced coloration also studied.

333. O. W. Florke, L. H. Lehnert, and H. Scholze

"Introduction to the Basis of Glass Structure," Glastech. Ber., 29, 169-74 (1956).

334. K. Grjotheim and J. Krogh-Moe

"Structure of Oxide Glasses," Glastek. Tid., 11, No. 2, 47-55 (1956). (In English.) Ceram. Abstr. 1956: 187b.

These authors are critical of the X-ray method of determining glass structure. They discuss examples in which it is difficult to reconcile the existence of three dimensional random network, and in which Zachariasen's rules are violated. It is suggested, therefore, that such rules are not necessarily valid for oxide glasses. It is pointed out that both the ionic and molecular concept of glasses may be justified depending on the position of the oxide cation on the electronegativity scale.

335. Kai Grjotheim and Jan Krogh-Moe

"The Structure of Vitreous Lithium Borates," Kgl. Norske, Videnskab. Selskabs, Forh., 29, 24-8 (1956).

The coordinations number of B changes from 4 to 3 on the addition of alkali metal oxide. There is a small but definite contraction of the B-O distance in these borates. The B-O distance is 1.45A in B_2O_3 glass and 1.35A in lithium borate glass. Similar contractions are observed in Na and K glasses.

336. R. Kruh

"Surface Tension and Structure of Molten Glasses," J. Chem. Phys., 25, 1085-6 (1956).

A letter to the editor to explain increase in surface tension of molten silicate glasses with temperature. Suggests phenomenon related to a notable entropy contribution caused by constraint placed on configuration of the polymeric structure.

337. M. Levy

"Radiation Coloration in Glasses," J. Soc. Glass Technol., 40, 18-24T (1956); Ceram. Abstr. 1957: 159h.

Radiation coloration is due to absorption in G centers formed in the glass. These centers are proposed as being electrons trapped in an oxygen ion vacancy in the neighborhood of a particular group of one of the cations in the glass. High valency cation additions may inhibit coloration, though sensitization may occur when very small amounts are added. The situation is analogous to that observed in alkali halides.

338. J. D. MacKenzie

"The Physical Chemistry of Simple Molten Glasses," Chem. Revs., 56, 455-70 (1956).

The physical chemistry of simple molten binary systems is reviewed principally in terms of electrical conductance and viscosity. Conductivity studies indicate features of the cation component, while viscosity determinations reveal the properties of the anionic component of the molten glass. The discrete anion concept of glass melts is emphasized, and evidence from electrical, viscosity, and density measurements put forward to support the hypothesis.

339. H. Moore and P. W. McMillan

"Study of Glasses Consisting of the Oxides of Elements of Low Atomic Weight. I.-III.," J. Soc. Glass Technol., 40, 66-161T (1956); Ceram. Abstr. 1957: 160c.

Silicate borate and aluminate glasses were made with low atomic weight oxides such as beryllia, lithia, megnesia, and soda in the belief that the properties of such glasses would be most likely to show variations in the structural changes caused by the differences in the coordination of the different ions.

340. Ivan Peyches

"Glasses and Molecular Structures," Mem. Soc. Ing. Civils France, 109, No. 3, 163-73 (1956); Ceram. Abst. 1957: 6i.

This is a review paper on the theories of the nature of glass and the methods of determination.

*Reprints will be available at nominal cost at the conclusion of the series, provided there is sufficient interest. Order from Reprint Dept., THE GLASS INDUSTRY, 55 West 42nd Street, New York 36, N.Y.

341. I. Peyches

"General Remarks on the Vitreous State," Silicates Ind., 21, No. 5, 209-18 (1956); Ceram. Abstr. 1956: 210j.

This is a review paper and discusses the work of Bachris in detail. In this latter the relationship between ionic conductivity, free energy change, electrostatic attraction, and viscosity have been established.

342. E. Plumat

"Structure, Thermal Treatment, and Viscosity of Glass. I.," Silicates Inds., 21, 391-96 (1956); Ceram. Abstr. 1957: 233i.

The activation energy and network constant as determined by viscosity measurements on glass do not vary in a continuous fashion. It is suggested that the discrete modifications of the flow constant at certain temperatures is due to ionic associations in the glass. The size of these ionic groups is related to the ratio of the polarizable network modifying cations to the highly charged nonpolarizable silicon cations.

343. E. Plumat

"Glass Structure, Thermal Treatment, and Viscosity," Silicates Inds., 21, 447-57 (1956); C. A. 51: 6963g.

Plots of log viscosity versus reciprocal temperature indicate discontinuities in activation energy. Activation energy plots for 12 simple alkali and alkali-RO-silicate glasses are given.

344. E. A. Porai-Koshits, D. I. Levin, and N. S. Andreev

"Structure and Opalescence of Sodium Borosilicate Glasses. IV. Effects of Heat Exposure at Constant Temperature," Izvest. Akad. Nauk, S.S.S.R., Otdel, Khim. Nauk, 1956, 287-93; C. A. 50: 13389c; Bull. Acad. Sci. U.S.S.R., Div. Chem. Sci., 1956, 277-81 (Engl. translation); C. A. 51: 1560c.

Light scattering by sodium borosilicate glasses increases with thermal exposure at 500-700°C. This is explained by increase in chemical heterogeneities in structure of the glass due to the heating. Experimental work using photoelectric photometer and low angle X-ray diffraction supports this belief.

345. Ingeborg Schulz and Wilhelm Hinz

"Stability of Phosphate Ions in Melts and Glasses of Binary Phosphate Systems," Glastech. Ber., 29 (8), 319-23 (1956).

When melts of sodium, lithium, and potassium pyrophosphates were quenched on a cold steel plate by pressing with a water filled steel beaker, crystalline material was obtained, which was found by paper chromatography to yield only pyrophosphate ions on solution in water. Orthophosphates of lead, cadmium, and zinc behaved in the same way on quenching and yielded only orthophosphate ions on solution in dilute cold ammonia (with the aid of H_2S in the case of Pb). Lead and bismuth pyrophosphates were completely glassy when quenched in this way, cadmium pyrophosphate was part glass and part crystals, and zinc pyrophosphate was glassy with traces of crystallization. By paper chromatography these quenched melts of higher valence cations were found to be disproportionated as follows: $2PbO \cdot P_2O_5$, 8.6 ortho-, 69.7 pyro-, 16.8 tri-, and 4.9% tetra-phosphate; $2CdO \cdot P_2O_5$, 16 ortho-, 37.8 pyro-, 29.3 tri-, 10.3 tetra, and 6.4% penta-phosphate. These figures are the result of 4 to 5 determinations, and the error is not greater than 5% of the average value, which is given. From these results and those of others (Westman and Crowther, 1954; Van Wazer, 1950; Strauss, Smith, and Wineman, 1953) it is concluded that the stability of polyphosphate ions in melts falls off with increasing degree of polymerization and with increasing field strength of the cation present in the melt. In sodium metaphosphate the polyphosphate chains range from 100 to 500 P atoms in length either because of the retention of traces of H_2O in the melt or of cross linking by PO_4 tetrahedra. Cyclic metaphosphates are rather unstable in melts. Orthophosphates are stable in all melts except when cations such as Si^{4+} and W^{6+} with extremely high field strengths are present, when P_2O_5 is easily split off. The instability of higher phosphates in the presence of cations with field strengths greater than those of the alkali ions is shown by the results of chromatographic analysis and by the tendency of P_2O_5 to evolve from long melts. The stability of a polyphosphate ion in a melt is greatest when the stoichiometric composition of the melt corresponds to that of the ion. The fact that all phosphate glasses with compositions between the pyro- and meta-phosphate limits contain principally phosphate ions which do not exist in crystalline compounds may be taken as evidence against the crystallite theory of glass structure. In general, melts having a large proportion of P_2O_5 tend to form glasses more readily than melts with a small ratio of phosphate to cation. With cations having high field strengths, glasses with relatively small proportions of P_2O_5 are formed; thus WO_3, with only 12% by weight of P_2O_5, readily forms a deep blue glass. In the pyrophosphate series, however, the tendency to form glass is not a simple function of the field strength of the cation; thus $Pb_2P_2O_7$ has less tendency to crystallize than either $Cd_2P_2O_7$ or $Zn_2P_2O_7$. This is probably due to the greater heat of crystallization of the zinc and cadmium pyrophosphates. This is borne out by the recalescence of $Zn_2P_2O_7$ on crystallizing, which is not observed with $Pb_2P_2O_7$. Preliminary measurements show that the heat of solution of $Zn_2P_2O_7$ glass is about 50% greater than that of $Zn_2P_2O_7$ crystals, while the heat of solution of $Pb_2P_2O_7$ glass is only 25 to 30% greater than that of $Pb_2P_2O_7$ crystals. 11 references.

346. V. V. Tarasov and E. F. Strozanor

"The Structure of Micro Heterogeneous Glass and Glassy B_2O_3 Determined by Specific Heat at Low Temperature," Trudy Moskov. Khem. Tecknol. Inst. im. D. I., Mendeleeva, No. 21, 26-33 (1956).

The analysis of the specific heat cumulation demonstrates a crystal structure similar to the orthorhombic modification of Sb_2O_3.

347. Leroy W. Tilton

"Structural Rearrangements in Silicate Glasses During Annealing," J. Soc. Glass Technol., 50, 338-52T (1956).

348. Adolf Dietzel and Emil Deeg

"A Dynamic Model of Glass Structure," Glastech. Ber., 30, 282-7 (1957).

A model is suggested. The formation of a framework with polarized O^{--} anions is the basis of the model. The framework is related to the operations of fusion, quenching, slow cooling, etc. In silica glass the tendency to form 6-member rings is striking.

349. George W. Brady

"Structure of Tellurium Oxide Glass," J. Chem. Phys., 27, 300-3 (1957).

TeO_2 glass is made up of octahedra which exhibit a close-order configuration such that 40 atoms are found at a distance of 1.95A and 20 atoms at 2.75A.

350. F. Herre and H. Richter

"The Structure of Vitreous B_2O_3," Z. Naturforsch 12a, 545-50 (1957).

Vitreous B_2O_3 consists of single and double layers of BO_3 group. Molten B_2O_3 is much less ordered.

351. Y. Hasegawa, M. Yanagi and S. Kawakubo

"Study on Silicate Glasses Colored with Tellurium," Yogyo Kyokai Shi, 65 (739), 179-86 (1957).

Silicate glasses are colored with tellurium by melting under reducing conditions, and the colors depend on the degree of reduction. Colors such as yellowish green, pink, purple pink, and red purple were obtained, and they are designated by the C.I.E. color system. These colorations were deepened by reheating. Red purple and purple pink were obtained only with the glass containing potassium, while the glass containing sodium gave orange pink to pink. The index of reducing capacity for various reducing agents was calculated, together with the ratio of reducing agent to tellurium necessary for the reduction of tellurium to telluride. The effects of glass composition on the effectiveness of reducing agents were studied. Aluminum is a good reducing agent. The failure of Springer (1955) to get red coloration with tellurium seems to be due to the selection of unsuitable reducing agents. 5 figures, 15 references.

352. Maurice L. Huggins and Tosio Abe

"Structure of Borate Glasses," J. Am. Ceram. Soc., 40, 287-92 (1957); C. A. 52: 1569e.

Properties of borate glass are discussed based on the structure having some of the boron coordinated by 4 oxygen atoms and an oxygen bridge between the boron atoms.

353. Ernest M. Levin and Stanley Block

"Structural Interpretation of Immiscibility in Oxide Systems: I. Analysis and Calculation of Immiscibility," J. Am. Ceram. Soc., 40 (3) 95-106 (1957).

Crystal chemistry principles are applied to the quantitative interpretation of immiscibility in 19 binary and 8 ternary glass systems. Two methods using ionic radii and one of two coordination types are given for the calculation of immiscibility in binary systems. The additive density method gives agreement with experimental results in both the borate and silicate systems to within about 5 mol. %. The maximum extent of immiscibility in ternary borosilicate systems can also be calculated. The importance of the electrostatic bond strength, defined as the valence divided by the coordination number, is discussed in relation to shape of liquidus curve, cation coordination type, and charge distribution on the network-former tetrahedra. Implications of the analysis in regard to the structure of glass are presented. 6 figures, 17 references.

354. Frida Oberlies and Adolf Dietzel

"Structure of Quartz Glass," Glastech. Ber., 30, 37-42 (1957).

355. Ikutaro Sawai

"Current Japanese Concepts of Glass Structure," Glass Industry, 38, 197-208, 234 (1957); C. A. 51: 10019i.

356. Werner Schwiecker

"Density and Structure of Glass," Glastech. Ber., 30, 379-86 (1957); C. A. 52: 1569f.

In silicate and phosphate glasses all added oxide brings about expansion; in borate glasses there is contraction followed by expansion. There is a linear relation between volume increase per mole and the ionic volume of network forming cations. The volume occupied by O^{-2} in the glass is 1.2 times that in the crystal. For cations the factor is about 2. For phosphate glasses the volume expansion is not quite linear for BeO, CaO, CdO, PbO and BaO additions. There is a discontinuity at 1 mole RO for MgO and ZnO additions.

357. Ivan Simon

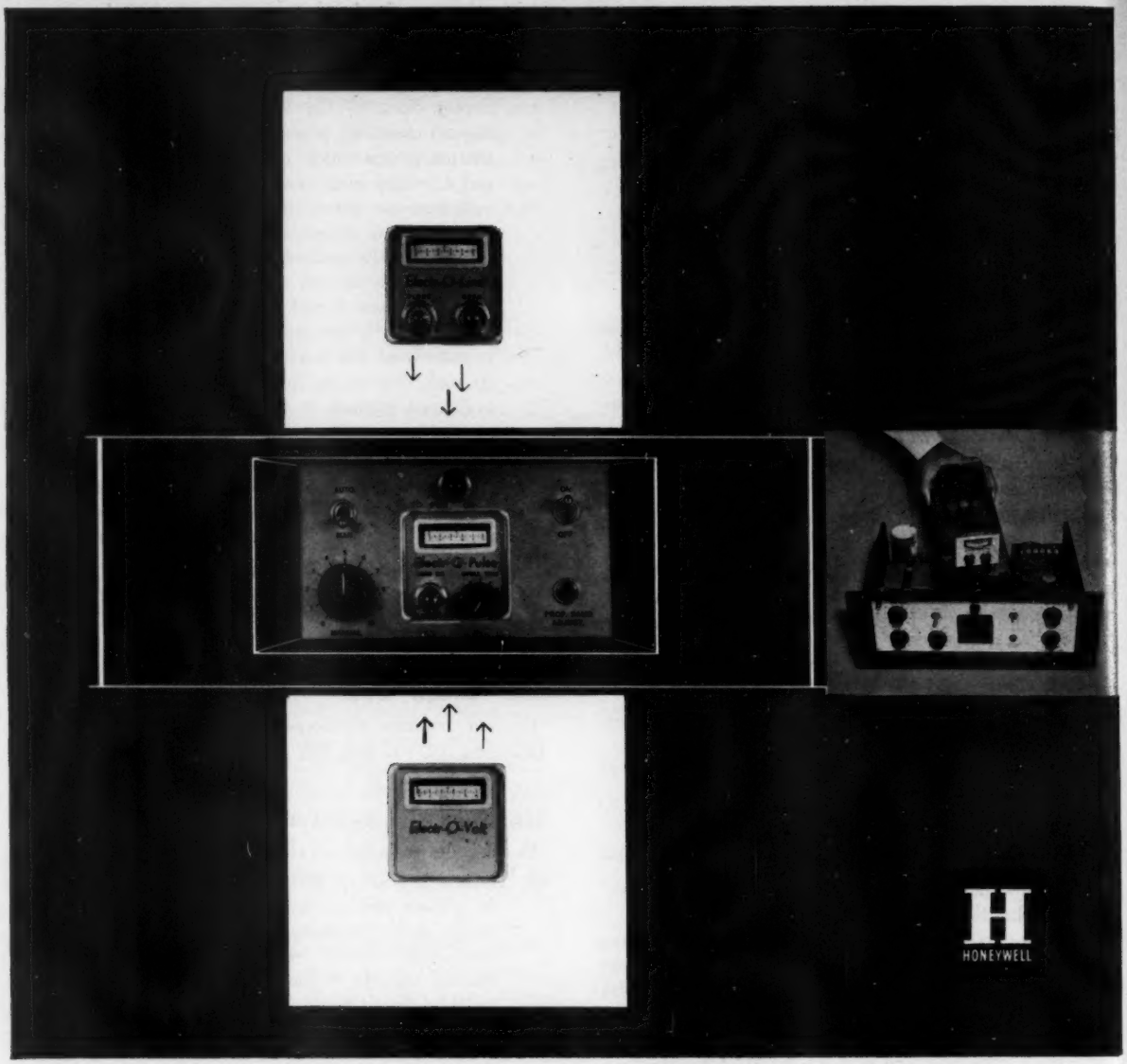
"Structure of Neutron-Irradiated Quartz and Vitreous Silica," J. Am. Ceram. Soc., 40, 150-3 (1957); C. A. 51: 13339b.

Si-O distances in irradiated quartz same as unirradiated vitreous silica; bond angle, however, is 138° versus 142° for silica. Infrared reflection curves differed except at the peak at 1100 cm^{-1}.

358. V. V. Tarasov

"Atomic Chains and Fine Structure of Glass," Zhur. Tekh. Fiz., 27, 1521-33 (1957); Kristallographiya, 2, No. 4, 489-96 (1957).

(To be continued in September)



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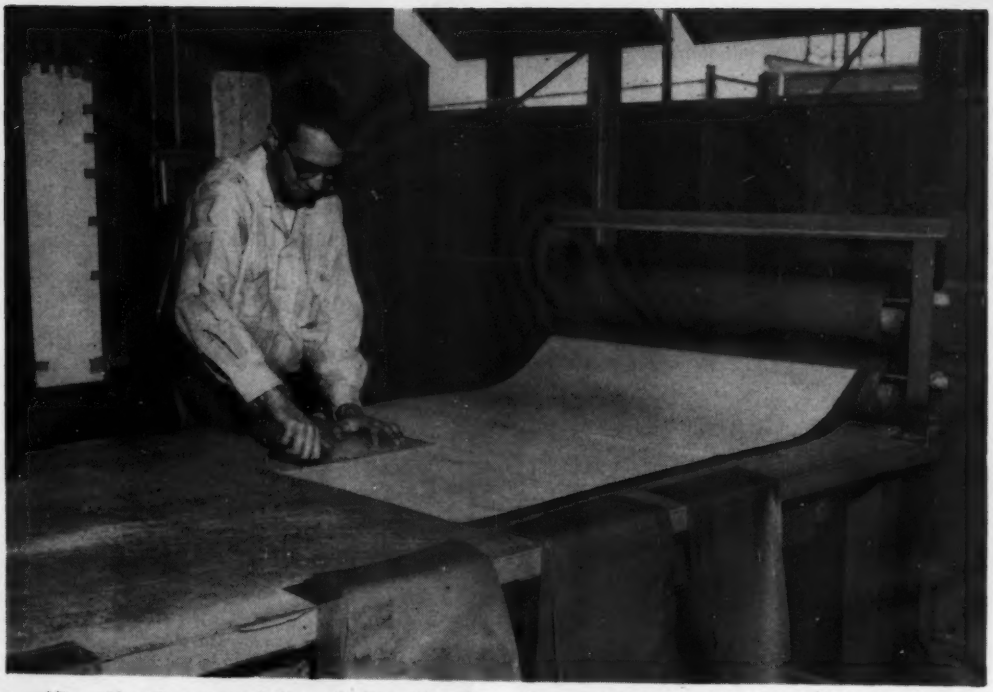


Vacuum bag molding with resin prepregs begins with the cutting of template shapes from a roll of preimpregnated glass cloth shown here at right. The cloth itself is tacky and is supplied with a polyethylene separator sheet.

PREIMPREGNATED FIBER GLASS MATERIALS

Producers of short-run parts having complicated 3-dimensional curves and configurations are finding that the use of preimpregnated fiber glass makes the operation practical in terms of cost savings and ease of fabrication.

Fiber glass materials preimpregnated with thermosetting diallyl phthalate resin are helping light aircraft manufacturers solve two growing problems: (*1*) production of parts having increasingly complicated 3-dimensional designs, and (*2*) the costly industry trend to yearly or bi-yearly model change-overs.

Prepregs for Cessna

At its Wichita, Kan., plant, Cessna Aircraft, for example, makes many parts of widely ranging configurations from glass cloth impregnated with diallyl phthalate resin. One of these parts, a fin tip beacon housing for its 310 business aircraft, won a design award at last year's meeting of the Society of the Plastics Industry.

The components are mostly for exterior use on the aircraft and are joined directly to the aluminum skin. They carry their load of structural and "working" pressures, and provide unusual weathering resistance.

Cessna's production method is essentially one of laying-up and vacuum bag molding the prepregs, which are supplied by Cordo Chemical Corp. and based on Food Machinery and Chemical Corp.'s "Dapon" resin. In the tacky state, they can be laid up by hand, one layer on another with little waste and no liquids. For the more complex shapes, a break-away plaster mold is used (the mold is broken out after the cure is complete). Metal-filled epoxy molds are used for simpler configurations.

The prepregs are cut to size from templates and built up to desired thickness on the mold. A PV-alcohol film bag is then fitted over the mold and the air withdrawn through a suction hose. The alcohol film ad-

heres tightly to the surface of the prepreg, and large wrinkles are removed by hand smoothing. The mold and bag are placed in an oven to cure at 250°F for about two hours. Use of the vacuum bag assures good surface characteristics of the molded prepreg as well as optimum flow of the resin.

The cured prepregs are easily parted from bag and mold and require little hand finishing. Flow characteristics of the resin result in homogeneous molding with a weave-free surface. Small ridges resulting from wrinkles in the bag are easily sanded off in a short operation. The parts are drilled for bolting or riveting and sent out to be incorporated in the aircraft.

Prepregs for Beech Aircraft

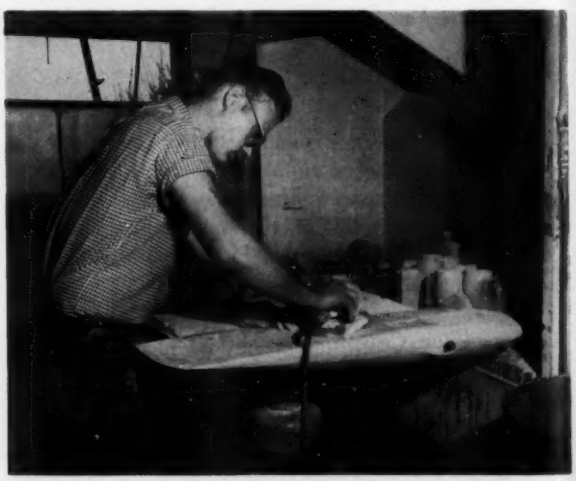
Beech Aircraft uses both break-away and matched dies, the latter for making parts to hold aluminum radar reflectors in target drones. Several of the company's Beechcraft parts are vacuum bag molded because of their intricate shapes.

The success of prepregs in meeting these production demands indicates that molding with resin-impregnated glass cloth may be the answer in many industries for making short-run parts that do not justify expensive metal forming work or for fabricating parts of more complicated design.

Pieces cut from the roll of preimpregnated glass cloth are layed-up by hand, one layer on another until the desired thickness is reached. The part shown here is a stabilizer section; the mold is metal-filled epoxy.

A PV-alcohol vacuum bag is fitted over the mold and the layed-up diallyl phthalate prepreg. The hose in the foreground is used to withdraw the air from the bag, causing the alcohol film to adhere tightly to the prepreg and mold during the curing operation.

The vacuum-sealed prepreg is placed in a circulating hot-air oven maintained at 250°F. Curing time runs about 2 hours, during which the vacuum is maintained by the hose connections shown inside the oven.



Light hand sanding is all that is needed to complete the piece. Shown here is the conical chamber wing tip for the Cessna 210 aircraft. After sanding, the piece is precoated and sent out to be incorporated with the aluminum wings.

Applications...

GIANT MILK BOTTLE of fiber glass was a featured display at the Royal Highland Show of agriculture and industry in Scotland this summer. The bottle, 30 ft. in height, has a capacity of 96,000 pt., and was built in 16 inter-linked sections based on a wooden frame. Inside, a spiral staircase enables visitors to climb up to the roof of the stand. *United Glass.*
Reader Service Card: Circle No. 50

FIBER GLASS coated with "Baymal" colloidal alumina has been found to be six times more heat resistant than untreated fiber glass according to manufacturers of the new chemical. Developed over a 15-year period, "Baymal" is a white, free-flowing powder consisting of clusters of minute fibrils of boehmite alumina. *E. I. du Pont de Nemours & Co.*
Reader Service Card: Circle No. 51

COMMERCIAL FISHING EQUIPMENT made of fiber glass reinforced plastics is reported to be increasing in use as fishermen become more familiar with the design and end-property advantages of the material. Typical of the products involved in this expansion is a spray-molded fish separator screen. Fiber glass enables the fabricator to meet the intricate, short-run design requirements of this apparatus economically, and also provides the advantages of high strength, exceptional weatherability, excellent corrosion resistance, and light weight.

As an industrial sea-going material, fiber glass is also making its appearance in striker boats, brine tanks for pickling operations, and handling equipment such as doff boxes, buckets, batch containers, and truck and conditioning boxes. *Carolina Fiberglass Products Co.*
Reader Service Card: Circle No. 52

NEW FIBER GLASS GUN ROVING product is soft, static-free, and features rapid wet-out. It is designed to work efficiently with all types of spray-up guns. Designated type "7170," the roving has a specially formulated chrome-type binder that is said to assure consistent performance at all times. More even distribution and better lay-down of individual fibers are two of the improvements claimed for this product. *Johns-Manville Corp.*
Reader Service Card: Circle No. 53

NEW POLYUNSATURATED MONOMER has been developed for special applications in a number of resin systems. Now available in pilot plant quantities, the monomer is trademarked ATAC (acetyl triallyl citrate). It is said to have significant potential in the preparation of glass cloth laminates, as well as in the fields of ceramics and glass. *Miles Chemical Co.*
Reader Service Card: Circle No. 54

NONCONDUCTIVE LADDER made of fiber glass reinforced plastic with polyurethrne core has been designed primarily for utility maintenance. Capable of supporting 2000 lb., the ladder is well suited for working around live wires and requires little maintenance. *American Allsafe Co.*
Reader Service Card: Circle No. 55

AIRPLANE UNDER-CARRIAGE of fiber glass reinforced plastic has been produced for use on an experimental light plane. The first of its type, this filament-wound part has proved successful in severe stress tests.

Designed for use on the Stol MFI-10, the fiber glass under-carriage has shown better shock absorbing and damping properties than conventional under-carriages, an important factor where a plane is used for landing on rough terrain as this type is. The result is a smoother ride on the ground with less vibration and wear and tear on instruments and electronic equipment. *AB Malmo Flygindustri.*
Reader Service Card: Circle No. 56

CATALOGS RECEIVED

Fiber glass material handling units (4 pages). Lists significant properties and complete specifications for tote boxes, industrial trays, tanks, and centrifugally molded pipe. Special sizes and shapes may be molded to users' specifications. *Apex Reinforced Fibre-Glass.*
Reader Service Card: Circle No. 57

Appliance and equipment quieting materials (13 pages). Brochure explains absorption of air-borne noise and reduction of structurally-borne sound. Suggests practical and economical solutions of these problems using existing fiber glass products. Illustrated with performance tables, nomographs, drawings, and photographs. *Owens-Corning Fiberglas Corp.*
Reader Service Card: Circle No. 58

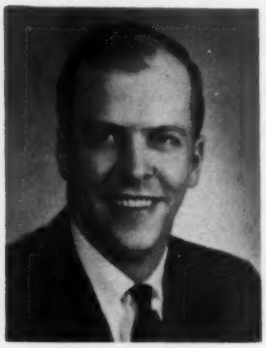
NEWS
IN THE GLASS INDUSTRY

Libbey-Owens-Ford Glass Co.

PAUL D. D'ARMIENTO, field sales representative in the Pittsburgh area, is the new president of the Producers' Council Pittsburgh chapter.

Thatcher Glass Mfg. Co.

NEAL M. GALUSHA named general manager of the company's Toledo Mould Div. . . . FRED J. RAYBURN, previously a vice-president of the Toledo Mould Co. before its acquisition by Thatcher, becomes sales manager of the division.



Neal M. Galusha

Owens-Illinois Glass Co.

HARRY M. SCHOTTELKORB named administrative manager of the new southern regional staff in Atlanta, Ga. . . . WALTER F. EITELBACH appointed administrative manager and ARNOLD R. ZINK plant engineer at the Libbey Glass Div. plant under construction at City of Industry, Calif. . . . CHARLES J. GRAHAM, formerly director of purchases at the Atlanta facility, made administrative manager for the New Orelans glass container plant scheduled for production this fall. JAMES L. SOMMERVILLE is plant manager. . . . JAMES T. WALKER, JR., transferred to Buffalo as salesman in charge of operations for the glass container division . . . ELMER P. LOTSHOW to be located at the general offices in Toledo, O., as manager of marketing and economic research for the marketing development department . . . The third and final contract for the construction of a 350,000-sq. ft. container plant in Brockport, N. Y., has been awarded to John W. Cowper Co., Inc., of Buffalo. The installation is expected to be completed early in 1962 . . . The Libbey Glass Div. will close its Buffalo plant by March, 1962. Glass tableware cutting operations will be moved to Toledo and City of Industry.

Wyandotte Chemicals Corp.

CARL SMITH elected vice-president, industrial chemicals marketing . . . CLINTON J. ALLEN, JR., appointed administrative assistant to president ROBERT E. SEMPLE . . . PATRICK O. MCELROY, manager of technical services at the company's Geismer Works near Baton Rouge, La., transferred to Wyandotte, Mich., as quality control manager . . . PIERRE C. FUGER, sales executive, named manager of national soda ash accounts . . . Twenty-four acres of industrial property have been purchased by the firm in Ontario, Calif. Exact use of the land has not been determined and construction dates have not been set.

Fred J. Rayburn

Harbison-Walker Refractories Co.

CHARLES R. HAUTH appointed assistant manager of technical sales. He has served most recently with technical sales in Pittsburgh.

Allied Chemical Corp.

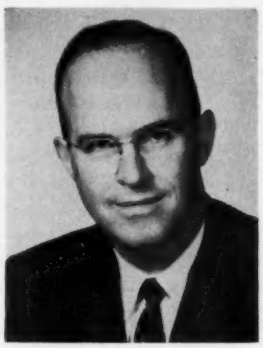
DR. CHARLES E. MC GINN appointed assistant director of research for the firm's Solvay Process Div.

Emhart Mfg. Co.

CHARLES ROUTOLO, formerly supervisor of specifications for the firm's Hartford division, appointed sales representative . . . Ground has been broken for the company's 160,000-sq. ft. administration and research center in Bloomfield, Conn. The new facility will house about 400 employees upon completion.

Mississippi Glass Co.

T. A. W. GILLIAM, eastern sales manager, has retired after 24 years of service.



Joseph F. Knight

Kaiser Refractories & Chemicals Division

JOSEPH F. KNIGHT, manager of operations since 1955, named vice-president of operations . . . The division has concluded a licensing agreement according to the terms of which Ceramica Olivos S. A., Buenos Aires, Argentina, will manufacture and market basic refractory products and fire clay specialties there. All products will be manufactured under Kaiser trademarks, formulae, and quality control methods.

American Potash & Chemical Corp.

PAUL E. MCCOY named assistant manager of boron products and glass and ceramic industry sales.

Brockway Glass Co.

M. C. ROBINSON has joined the firm's staff as glass container products manager. He was formerly a regional sales manager for Hazel-Atlas.

Pittsburgh Plate Glass Co.

CLYDE C. RUDDICK, manager of safety and plant protection, named a Fellow of the American Society of Safety Engineers . . . CHARLES S. CUSICK appointed to the newly-created position of chief production engineer, primarly glass, with headquarters in the Pittsburgh general office. The assignment consolidates the responsibilities of WILLIAM C. ELY, production engineer, plate glass, and M. F. ALLISON, production engineer, window glass, who's retirements become effective later this year. RAY C. JOINER will succeed Cusick as assistant manager at the Ford City, Pa., plant . . . JOHN W. HATFIELD, safety engineer at the Ford City plant for the past 25 years, died May 31 at the age of 64. He had been with the company for

Clyde C. Ruddick

41 years, during which he served in various supervisory capacities . . . PPG has been honored by the Steel City chapter of the Society of Handling Engineers at its first annual award dinner in Pittsburgh recently. The company received a plaque in recognition of furtherance of industrial packaging in the tri-state area (Pennsylvania, Ohio, and West Virginia).

American Ceramic Society

The following men have been newly installed as Fellows of the Society: Warren R. Beck, Myles P. Bennet, M. K. Blanchard, John Boros, Neill M. Brandt, George W. Brindley, Wayne E. Brownell, J. E. Burke, Van E. Campbell, William P. Charbonnier, George P. Cole, Ivan B. Cutler, Alfred R. Decker, Charles J. Deignan, George T. Faust, Richard J. Galvin, Ralph L. Gibson, James C. Hicks, Arno M. Illing, James R. Johnson, Robert J. McEvoy, Arnulf Maun, Howard S. Orth, Sr., James S. Owens, Theodore J. Planje, James E. Price, Robert F. Rea, Hal H. Price, Guy E. Rindome, Rustum Roy, and J. H. Westbrook.

Perkin-Elmer Corp. Symposium

JOHN C. ATWOOD, director of research for the firm's instrument division, predicted, in his address to more than 100 scientists and engineers, that optical masers will revolutionize many space age applications of optics. Speaking at the company's 2-day symposium held last month in Connecticut, Atwood went on to estimate that "from 10 to 20 different types of optical masers, with different characteristics, will be available in the next 10 years." He also stated that there are probably thousands of types of masers possible in the future.

Eugene R. Crandall

H. K. Porter Co., Inc.

EUGENE R. CRANDALL named manager of mullite operations within the refractories division.

Scientific Glassblowers Seminar

A special seminar for scientific glassblowers will be held during the week of August 28 at the State University of New York College of Ceramics at Alfred University. This comprehensive training program is being sponsored by the University and has been prepared with the cooperation of the American Scientific Glassblowers Society.

Seminar Topics

PROPERTIES OF GLASS, Dr. C. H. Greene
VACUUM PRACTICE, Dr. T. J. Gray
ELECTRON MICROSCOPE, W. B. Crandall
PHYSICAL CHEMISTRY, Dr. D. R. Rossington
X-RAY, Dr. W. E. Brownell
DISTILLATION PRACTICE, Dr. D. R. Rossington
HIGH-TEMPERATURE MATERIAL, Dr. W. G. Lawrence
SPECTROSCOPY, W. B. Crandall
INTRODUCTION TO SELECTED ELECTRONIC TECHNIQUES, Dr. T. J. Gray
INTRODUCTION TO SEMICONDUCTORS, Dr. T. J. Gray
GLASS-TO-METAL AND GLASS-TO-CERAMIC SEALING, A. J. Hawkins

For further information, inquiries should be sent to Dr. Thomas J. Gray, State University of New York College of Ceramics at Alfred University, Alfred, N.Y. Registrations will be accepted through August 12.

FMC Corp.

Food Machinery and Chemical Corp. has changed its name to FMC Corp. as of July 1 of this year.

Vitro Chemical Co.

ROBERT E. LEVITAN appointed to the newly-created position of manager, marketing services . . . H. HOLT APGAR named a product supervisor with responsibility for metallurgical activities.

Robert E. Levitan

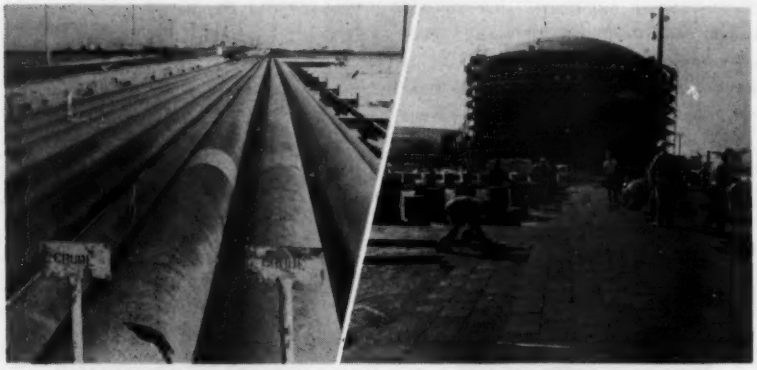
W. P. Fuller & Co.

ROY O. BRECHWALD, Hawaii district manager for the past 4 years, appointed vice-president and general manager of Fuller Panama Corp. He will be succeeded by T. B. CARMICHAEL in Hawaii . . . ROAY ST. DENNIS named manager distribution services, with headquarters in San Francisco . . . L. R. TEMPLETON made manager of glass distribution in the bay area.

Imports Increase in 1960

U. S. imports of pressed and blown glassware reached a record high of $24.3 million in 1960 according to the Consumer Durable Goods Div., Business and Defense Services Administration, U. S. Department of Commerce. This is 4.0 per cent above the previous high of $23.4 million in 1959.

NEW APPLICATIONS IN GLASS...



Cellular Glass in Oil Plant

A plant designed specifically to make fully refrigerated liquified petroleum gas available for tanker shipment will have tanks and pipe lines insulated with high-strength glass foam. The $7 million facility, being constructed by the American Arabian Oil Co. at Ras Tanura, Saudi Arabia, will supply 4,000 barrels daily of high-purity propane, butane, or a blend of the two.

The cellular "Foamglas" has been chosen to meet the stringent requirements of holding refrigerated propane gas at –43°F and refrigerated butane gas at 0°F while outside temperatures go as high as 120°F. Two 2-in. thick layers of the material will be incorporated in the foundation for the steel bottoms of the storage tanks. Glass insulation will be adhered to the steel tank walls, and will also be used to cover piping and equipment. *Pittsburgh Corning Corp.*

Reader Service Card: Circle No. 59

Improved Heat-Resistant Glass

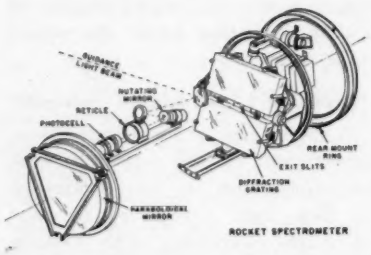
Silica glass (composed of several metallic oxides) heated to a temperature of approximately 660°C and sprayed with a 10 per cent solution of polyethylsiloxane (an organo-silicone polymer) is said to possess improved heat resistance, mechanical strength, and uniform hardness, and to be free from optical distortions.

According to the Mendeleyev Institute of Chemical Technology in Moscow where these properties were investigated, the improvements result from the cementing over of microcracks on the surface of the glass, the increased concentration of silicon dioxide in the surface layer formed by the breakdown of the organo-silicon compound, and the increased hardness of the glass brought about by the cool spray.

Reader Service Card: Circle No. 60

Rocket-Borne Spectrometer

Built to study ultraviolet energy emitted by the stars, this special instrument will be carried above the earth's atmosphere in an Aerobee-Hi rocket. Similar studies from the ground are prevented by the opacity of the earth's atmosphere.



ROCKET SPECTROMETER

The spectrometer has been designed to fit into a package 30 in. long and 14 in. in diameter. In operation, it will scan the ultraviolet regions of the spectrum during a period lasting less than 5 minutes. The ultraviolet light emitted by the stars will be recorded when the rocket is some 62 to 143 mi. above the earth. Detailed information will be telemetered back to earth immediately because the entire spacecraft will be destroyed on reentering the earth's atmosphere. *Perkin-Elmer Corp.*

Reader Service Card: Circle No. 61

Dating of Glass

Tiny separated layers of weathering crusts, which form slowly as glass objects buried in soil or submerged under water undergo chemical deterioration, can be counted in cross section under a microscope to determine the length of time for which the glass has been buried.

The technique, developed by Dr. Robert H. Brill, administrator of scientific research, The Corning Museum of Glass, and Harrison P. Hood, manager of chemical research, Corning Glass Works, is similar to the counting of rings in a tree to measure its age, except that here a process of destruction rather than growth is involved. The validity of this dating method is said to have been proven by the examination of objects buried for known periods of time. Although not all pieces of glass are equally susceptible to weathering, it is hoped that this approach will serve as a valuable tool for archeologists. *Corning Glass Works.*

Reader Service Card: Circle No. 62

Radiation Dosimeter Reader

A new line of special glasses becomes flourescent when exposed to radiation. These materials are being used as a simple means of reading ionizing radiation dosage on the standard flourometer. The silver activated glass quickly converts this instrument for application in food and drug sterilization, space medicine and research, plastic modification, and many other fields. *G. K. Turner Assoc.*

Reader Service Card: Circle No. 63

CATALOGS RECEIVED

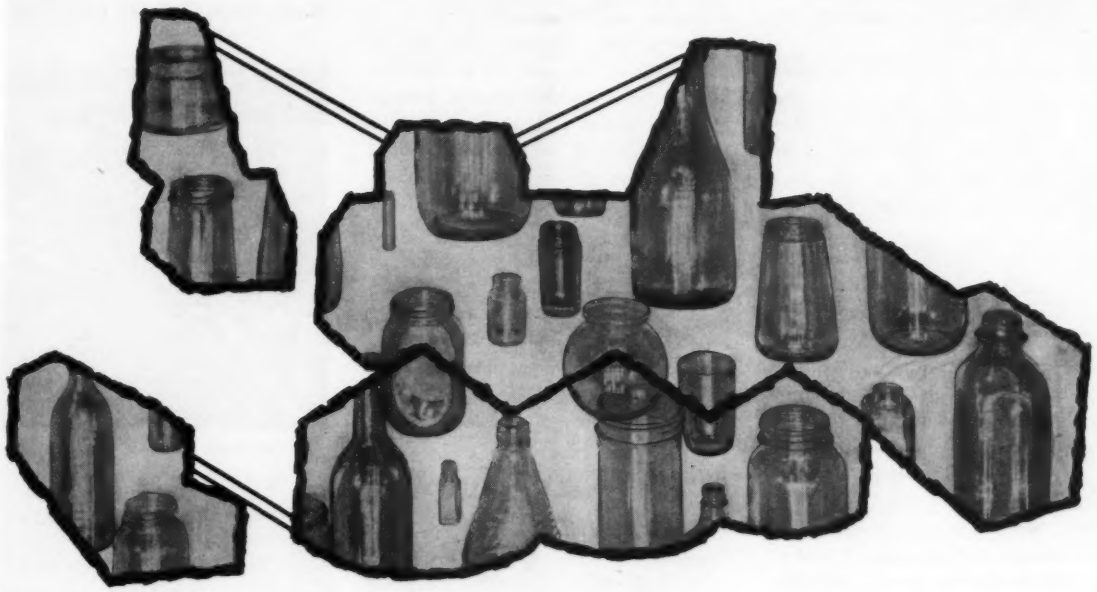
Precision optics. Brochure describes custom made and mass produced optics. Design and engineering services are listed. *Plummer & Kershaw.*

Reader Service Card: Circle No. 64

WEST END

advance planning

OF MULTIPLE SODA ASH SOURCES ANTICIPATES INDUSTRY'S GROWING NEEDS



WEST END has new production facilities now under construction at a second natural source in Wyoming. Produced under the same uniform management and controls that have served the requirements of western industry economically and dependably for 36 years, high quality West End soda ash from Wyoming will be available to industrial users in an ever-broadening market.

Stauffer CHEMICALS

WEST END CHEMICAL COMPANY • DIVISION OF STAUFFER CHEMICAL COMPANY

636 CALIFORNIA STREET, SAN FRANCISCO, CALIFORNIA • PLANT: WESTEND, CALIFORNIA

NEW EQUIPMENT AND SUPPLIES

New Heat Recovery Method

A compact Ljungstrom® air preheater has been purchased by a leading glass manufacturer for installation on a plate glass tank at one of their eastern plants. This rotary regenerative air preheater is the first installation in the glass industry designed primarily for heat recovery purposes.

Scheduled to be placed in operation in September of this year, the Ljungstrom is guaranteed by the manufacturer to raise the temperature of incoming combustion air for the brick regenerator from ambient to about 950°F.

Rotary regenerative air preheaters are used extensively in utility power generating stations and have been selected for approximately 90 per cent of all boiler heat recovery applications. In utility applications, the air preheater is claimed to offer lower capital investment, minor maintenance, definite size advantages, and complete adaptability to all fuels.

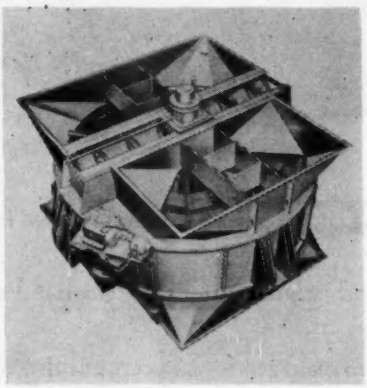
Since fuel costs are becoming an increasingly important primary cost in glass production, it seemed advisable to investigate the possibilities of applying to a glass furnace heat recovery equipment which had attained such high performance records with utilities. Tests were conducted on a plate glass tank at the company's plant to evaluate the effect of dust build-up in flue gases on the preheater. These tests also provided data on the adaptability of heating surface material in temperatures ranging from 1100°F to 1500°F and and criticality of deposit build-up on heating surfaces. The high flexibility of the test unit, which was moved to various work points during the test, was a prime factor in the extensive data obtained on temperatures, condensation, and flow conditions.

Layer of heating elements used on boiler.

Test results indicated that the deposit build-up dropped off as direction of flow was changed during passage of waste gases and air between the checkerwork and the test unit. Deposit accumulation on the heating surface at the 1100°F temperature encountered in the tests was nil.

Because this was the first test of its kind in the glass industry, test procedure was developed as information was accumulated, thus making it possible to vary test requirements to meet changing conditions.

All data from the test was carefully analyzed in relation to capital cost of the preheater, fuel savings, maintenance costs and ease of installation in limited available space. It is considered fully representative of actual production conditions which would be encountered by the air preheater. The first Ljungstrom, purchased by the glass industry based entirely on its heat recovery capabilities, was selected after the analysis.



Typical air preheater unit.

Annual savings have been projected only on fuel costs. Recovery of capital outlay for the unit is expected within 18 months. Additional savings are anticipated from increased tank life, lower maintenance costs, better glass quality and higher productivity. Annual fuel savings on the glass tank are estimated at 11 to 13 per cent. *The Air Preheater Corp.*

Reader Service Card: Circle No. 65

Built-in handle facilitates vibrator handling.

Portable Railroad Car Vibrator

Combines light weight and heavy impact in an air-powered unit weighing less than 70 lb. Creates a vibratory force of over 1000 lb., and is designed to fit a standard railroad hopper care bracket. Can be lifted from its bracket mounting and moved without loosening or tightening bolts, clamps, and other attaching devices. *The Cleveland Vibrator Co.*

Reader Service Card: Circle No. 66

Miniature TV Camera

A closed-circuit television camera, claimed to be one of the smallest in the world, is currently being introduced to the U. S. market. Known as the "Minicamera," the pocket-size TV eye is small enough to scan the inside of a 3-in. pipe. It is strongly built to withstand heavy industrial use, and because the casing does not require ventilation holes, the camera is protected against dust. In addition, the camera will operate without special protection where there is considerable noise or vibration. *Fairbanks, Morse & Co.*

Reader Service Card: Circle No. 67

Molybdenum Booster Electrodes

For use in speeding up glass furnace melting processes are now available in ready-to-use standard sizes with threaded ends. On the market in six standard lengths, 1¼ in. in diameter, these electrodes eliminate material loss during machining and the extra costs of machining and handling by the user. *Sylvania Electric Products Inc.*

Reader Service Card: Circle No. 68

Relay Rack Chart Recorders

Strip chart recorders of the "ElectroniK 15" line are now being manufactured in 13 standard relay rack models. All include new speed chart changers and new recording and operating pens. The rack-mounted recorders are identical electronically and in performance with corresponding models for surface and flush mounting. *Brown Instruments Div.*

Reader Service Card: Circle No. 69

Narrow Aisle Transveyor

Reduces storage handling costs by enabling the user to shrink areas of nonusable existing enclosed storage space. The lift truck, now in national

One operating lever replaces cluster of controls.

distribution, is fully operational in narrow 6-ft. aisles. *Automatic Transportation Co.*

Reader Service Card: Circle No. 70

Cabinet-Type Dust Collector

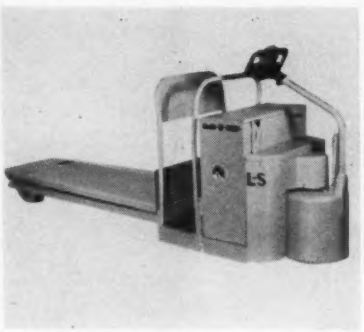
Three models are powered with ½-, 1-, and 1½-hp motors affording 400-, 600-, and 900-cfm capacities, respectively. All models mounted on rubber supports, portable, completely fireproof, and equipped with exhaust silencers and aluminum alloy impellers for spark resistance. High efficiency is claimed. *Vacculator Co., Inc.*

Reader Service Card: Circle No. 71

Break-Resistant Saw Blades

A new series of break-resistant saw blades is now on the market for use with power hand saws. The blades, called "Tuffies," feature nylon reinforcement combined with abrasive grains. In addition, more cutting edges are exposed. These two factors are said to produce a blade which retains break-resistant qualities for life, and at the same time, cuts faster. *Eveready BrikSaw Co.*

Reader Service Card: Circle No. 72



Designed for fast traction speeds over long runs.

Rider-Type Walkie

Comes equipped with "StanDrive" operator's compartment for ordering picking, movement of supplies, or servicing of equipment where both walkie operation and long runs are required. Features two speeds in either direction, high and low, plus an additional selective over-drive when riding. Both platform and pallet styles are available. *Lewis-Shepard Products, Inc.*

Reader Service Card: Circle No. 73

New Glazing Adhesive

Has been developed for bonding and sealing window panes to aluminum frames in the manufacture of aluminum storm windows and doors. Called "Stormbond," it is a fast-drying solvent-type adhesive and sealer. It is said to have excellent adhesion to glass and aluminum, and to possess superior water resistance. *Anchor Adhesives Corp.*

Reader Service Card: Circle No. 74

Portable Potentiometers

Three new low-cost models provide on-the-spot measurements of temperature. They are applicable in instrument

Indicates degrees F in 15 temperature ranges.

maintenance departments and testing and research work.

All three instruments have a basic accuracy of ±0.3 per cent of range, and are equipped with a pointer galvanometer which has a sensitivity of 0.6 μa per scale division. The units measure 7 in. by 6 in. by 5 in. and weigh only 4½ lb. *Leeds & Northrup Co.*

Reader Service Card: Circle No. 75

Sample Preparation Eliminated

An automatic flame photometer eliminates sample preparation in sodium and potassium analysis. Permits continuous, automatic, and uninterrupted analyses of sodium and potassium simultaneously from the same sample. Cancels effects of environmental variations. *Technicon Controls, Inc.*

Reader Service Card: Circle No. 76

Flat Wire Belting

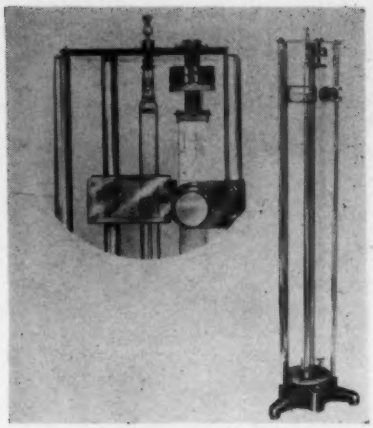
Is now available in mesh sizes up to 1 in. by 1 in., ½ in. by 1 in., and ½ in. by ½ in. Any width up to 12 ft. can be supplied in carbon steel, galvanized steel, or stainless steel. Although standard width of wire is ⅜ in., wire widths and rod diameters can be varied to meet strength requirements. *Cambridge Wire Cloth Co.*

Reader Service Card: Circle No. 77

Sale-Leaseback Plan

Glass manufacturers can now sell their existing plant and equipment and immediately lease it back for periods of 3 to 12 years. The plan is designed specifically for firms which have an overly large investment in fixed assets and whose growth, as a result, is being hampered by tight capital work. *Nationwide Leasing Co.*

Reader Service Card: Circle No. 78



Scales can be changed to other pressure units.

Improved Manometer

This precision mercurial manometer is a primary pressure standard with a range of 800 mm of mercury, or equivalent, and a guaranteed accuracy of 1/5000. A new vernier and float increase readability to 0.01 mm of mercury.

The vernier has scales in five different pressure units and reads in tenths of the main scale graduations. Thus, direct readings to within 0.001 in. of mercury can be taken. The well of the manometer is lined with stainless steel to protect the mercury from contamination. *Wallace & Tiernan Inc.*

Reader Service Card: Circle No. 79

Electric Furnace

Has a wide range of temperatures which makes it applicable for heat-treating, drawing, and glass annealing, among other operations. Temperature can be controlled from 300°F to 2300°F with fans removed; with forced convection fan, 150°F to 1875°F temperatures can be accurately controlled.

Zone gradient control operates by multiple circuits, with each circuit having its own input controller; gradients are indicated by a pyrometer and thermoncouples located zonewise. *L & L Mfg. Co.*

Reader Service Card: Circle No. 80

Battery Boosts Electric Truck Power

A new high-capacity battery for use in industrial trucks provides 85 ampere-hours per positive plate at the 6-hour rate. Rating of this "HY" battery is based on discharge of 1.75 final volts per cell. *C&D Batteries, division of The Electric Autolite Co.*

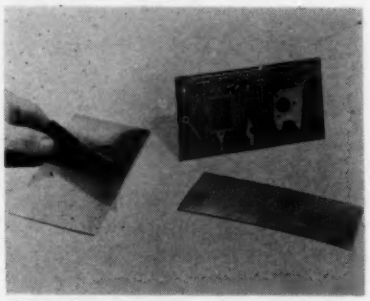
Reader Service Card: Circle No. 81

Thermosetting Adhesive

A new liquid synthetic resin-base thermosetting adhesive is now available for bonding copper foil to epoxy glass materials in printed circuit manufacture. Designated "EC-2080," the adhesive cures to a clear amber film. The bond between the foil and epoxy glass base can be immersed in a 500°F solder bath for 10 seconds without blistering or losing adhesion. This time can be increased by a long predry of the coated foil prior to bonding.

Peelback strength of cured bonds is 10 lb. per inch width on 1-oz. foil. The cured adhesive is not affected by normal cleaning solvents or by etching solutions of ferric chloride or amonium persulfate. Another adhesive, "EC-2130," is essentially the same as "EC-2180," except that the former resists chromic acid solutions. *Adhesives, Coatings and Sealers Div., Minnesota Mining and Mfg. Co.*

Reader Service Card: Circle No. 82



Finished printed circuit is shown at top right.

Three Films Available

The three 35-mm film strips, accompanied by printed scripts, are entitled "The Outdoor Storage and Reclamation of Bulk Materials," "Roller, Wheel, and Live Roller Conveyors and Related Materials," and "Narrow-Aisle Trucks". All are designed for use by educational institutions, industry, and trade and professional groups. *The Material Handling Institute, Inc.*

Reader Service Card: Circle No. 83

CATALOGS RECEIVED

Thirty-five ways to reduce shipping costs (16 pages). Booklet outlines little-known, often neglected opportunities for substantial savings in transportation costs. Examines methods, privileges, and alternatives available to management in this area. *Institute for Business Research, Inc.*

Reader Service Card: Circle No. 84

Management guide to productivity (26 pages). Compiled and simplified from analytical procedures developed and used by Professor James R. Bright, Harvard Graduate School of Business Administration, at the Industrial Management Center, Lake Placid, N. Y. Enables management to expose unwarranted handling expense and reduce costs with corrective materials handling measures. *Yale Materials Handling Div.*

Reader Service Card: Circle No. 85

Measurement of surface microfinish (6 pages). Describes two models of the "Surfindicator" designed for use on glass or other materials regardless of shape or composition. *Brush Instruments, division Cleavite Corp.*

Reader Service Card: Circle No. 86

Management of materials flow (16 pages). The warehousing approach is explained in detail in this brochure. Covers equipment and techniques for live storage and transportation of raw materials and finished products. *Rapids-Standard Co., Inc.*

Reader Service Card: Circle No. 87

How to reduce ware cost (8 pages). Discusses the use of spray lubricants, swabbing compounds, and spray equipment in glass production. Complete mold lubrication programs are outlined. *Renite Co.*

Reader Service Card: Circle No. 88

Sizing charts (4 pages). Shows how to size sliding gate regulators and control valves. Simplified charts cover steam, liquid, and gas service, and cross-referenced compiling eliminates need for rulers, formulas, or slide rules. Write for bulletin JSC-1. *OPW-Jordan Corp.*

Reader Service Card: Circle No. 89

Index of ASTM publications (62 pages). Lists and describes all symposia, manuals, special publications, compilations of standards, charts, reference photographs, and reports put out by the Society over the last several years. More than 300 items are included. *American Society for Testing Materials.*

Reader Service Card: Circle No. 90

Wetting agents (12 pages). Suggests applications for a wide variety of specialized uses. Also contains Draves wetting times for the various agents listed. *Nopco Chemical Co.*

Reader Service Card: Circle No. 91

Glass makes its *mass market* appeal because people all up and down the line agree that beverages "from glass" look and taste better to the thirsty. Helping glass people meet the mass market for beverages is a job Diamond likes to do well—through **(1) Absolute purity and uniformity of Diamond Soda Ash. (2) Service and deliveries of soda ash best suited to the industry. (3) Diamond technical assistance.** Diamond leadership in "chemicals you live by" is nowhere better symbolized — or more important — than in its service to the glass industry. Diamond Alkali Company, Cleveland 14, Ohio.

Diamond Chemicals

INVENTIONS AND INVENTORS

Tube and Cane Machines

Fluoro-carbon ceramic and glass products. Patent No. 2,887,526. Filed February 26, 1952. Issued May 19, 1959. No sheets of drawings; none reproduced. Assigned to United States Gasket Company by Merritt A. Rudner.

The arrangement of the materials is such that a body of Teflon powder, for example, is superimposed by a first layer of a Teflon-glass or Teflon-ceramic mixture containing 40 per cent glass powder or ceramic powder by weight, and is then covered by a second layer of a mixture of Teflon and glass or ceramic containing about 70 per cent of glass or ceramic powder by weight.

The column of material is subsequently subjected to sufficient compression to reduce the height of the column to about one fourth of its initial height.

The important feature is that a body of pure fluorocarbon resin, such as Teflon, is now integrally bonded in a unified body structure, with a portion of its body, in a predetermined transition region, containing a gradually or equivalently preponderant content of glass or ceramic, with the minor proportion of Teflon serving as a cohesive bonding medium with the pure Teflon body, so that as a result, one surface of the Teflon body is so preponderantly glass or ceramic that a glass or ceramic layer may be readily directly cemented or bonded thereto, for mechanical connection, or for mechanical sealing to withstand vacuum or for mechanical structural support.

The depth of the Teflon material in the body is not limited to any specific dimension, but may be varied according to the dimension that is ultimately desired, for the structure or operation required.

There were 6 claims and 16 references cited in this patent.

Machine for the Manufacture of Small Glass Bottles or the Like From Glass Tubes. Patent No. 2,935,819. Filed June 7, 1955. Issued May 10, 1960. Three sheets of drawings; none reproduced. By Jakob Dichter.

According to the invention a machine for the manufacture of small glass bottles from glass tubes includes two groups of holders which viewed in plan run through two adjacently disposed and mutually contacting closed paths containing working stations. At the contact point of the paths a separated piece of the glass tube, which

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until then has been carried by a holder of the first group, is taken over by a holder of the second group, characterized in that in the vicinity of the separation point (either at the separation point itself or in the working station following it) a burner device or cutter device is provided, which forms the lower end of the tube stock with a smooth-edged opening.

The drawing off and the separation of the body of the bottle from the tube stock requires only a little time and not more than the other operations, since the tube has already been drawn so far out of the holder at the first station that the potential separation point is exposed and can be heated before the drawing-off station.

Because of the fact that the glass tube does not drop down freely after the separation and opening of the bottom on the feed stroke, but is gripped by tongs and guided down without rotation, detrimental deformation of the soft edge of the tube is avoided.

There were 8 claims and the following references cited in this patent.

United States Patents

1,024,116, Burrows, Apr. 23, 1912; 1,587,466, Brown et al., June 1, 1926; 1,749,016, Boals, Mar. 4, 1930; 2,151,840, Dichter, Mar. 28, 1939; 2,266,417, Eisler, Dec. 16, 1941; and 2,595,077, Hughes et al., Apr. 29, 1952.

Foreign Patents

626,567, Great Britain, July 18, 1949.

Miscellaneous

Glass-Making Material and Method. Patent No. 2,934,-444. Filed April 13, 1955. Issued April 26, 1960. No sheets of drawings. Assigned to Corning Glass Works by Rowland D. Smith.

New borate compositions have been discussed that can be synthesized from borax and boric acid by heating these materials to a temperature at which substantially complete dehydration or release of chemically combined H_2O occurs. It has been found that such borate compositions can be used as glass-making batch materials and, when so used, substantially avoid the problems heretofore encountered.

There were 6 claims and the following references.

United States Patents

2,096,266, Suhr, Oct. 19, 1937 and 2,722,519, Ottey et al., Nov. 1, 1955.

Foreign Patents

293,410, Switzerland, 1953.

Other References

Mellor: Comprehensive Treatise on Inorganic and Theoretical Chemistry, v. 5, pages 66, 70 (1924).

Chem. Abstracts 31, 9348; 32, 4163; 41, 7693[a]; 47, 3534[b], 3664[b], 11842[b]; 48, 14141[e].

Morey: Properties of Glass, 2nd edition (1954), page 236.

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Industrial Building Exposition and Congress

September 25-28
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New York, N. Y.
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Union Scientifique Continentale du Verre (USCV)

September 26-29
Florence, Italy
The USCV is promoting its third symposium in cooperation with the Glass Experimental Station at Murano. The meeting will be devoted to a study of the mechanical properties of glass and means of improving them.

American Gas Association

October 2-4
Dallas, Texas
Annual convention.

Pittsburgh Section, American Ceramic Society

October 10
Pittsburgh, Pa.
A joint meeting to be held with the Pittsburgh Ceramic Association.

Exposition of Chemical Industries

November 27-December 1
New York Coliseum
New York, N. Y.
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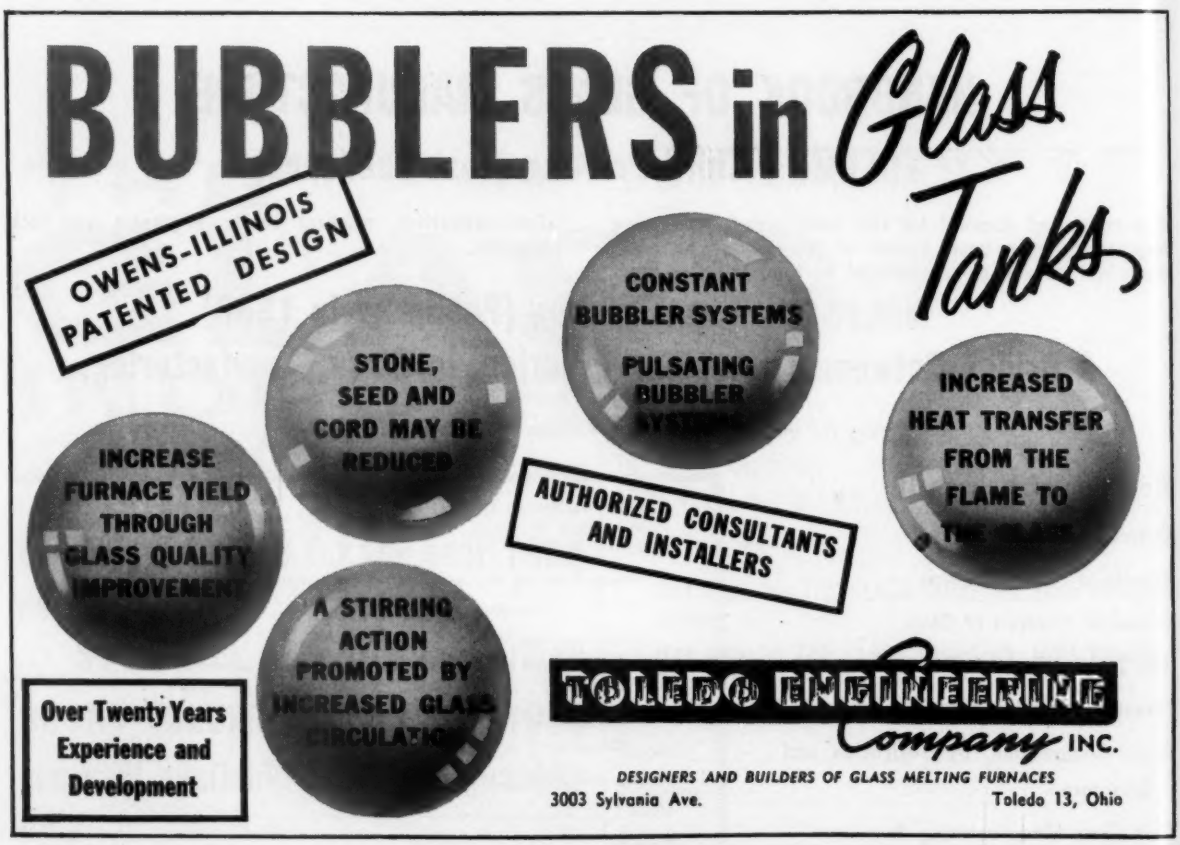
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CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during April, 1961, was as follows: *Flat Glass*: a preliminary figure of 22,100 for April, 1961, indicates a decrease of 4.7 per cent under the adjusted figure of 23,000 for March, 1961. *Glass and Glassware, Pressed and Blown*: an increase of 0.8 per cent is shown by the preliminary figure of 87,000 reported for April, 1961, when compared with the adjusted figure of 86,300 reported for March, 1961. *Glass Products Made of Purchased Glass*: the preliminary figure of 12,600 given for April, 1961, is 2.3 per cent under the adjusted figure of 12,900 reported for March, 1961.

Payrolls in the glass industry during April, 1961 were as follows: *Flat Glass*: a decrease of 8.01 per cent is shown in the preliminary $11,280,445.54 given for April, 1961, when compared with March's $12,263,117.94. *Glass and Glassware, Pressed and Blown*: a decrease of 2.2 per cent is shown in the preliminary $35,318,412.99 given for April, 1961, when compared with the previous month's adjusted $36,105,853.41. *Glass Products Made of Purchased Glass*: a preliminary figure of $4,056,467.94 was reported for April, 1961. This is a decrease of 1.8 per cent when compared with the adjusted figure of $4,131,810.14 for March.

Glass Container Production based on figures released by the Bureau of the Census, Industry Division, was 14,127,000 gross during May, 1961. This is an increase of 4.3 per cent over the previous month's production figure of 13,538,000 gross. During May, 1960, glass container production was 13,553,000 gross, or 4.2 per cent more than the May, 1961, figure. At the end of the first five months of 1961, glass container manufacturers have produced a preliminary total of 67,643,000 gross. This is 2.7 per cent more than the 65,801,000 produced during the same period in 1960.

Glass Container Shipments during May, 1961, came to 13,656,000 gross, an increase of 23.2 per cent over the April figure of 11,084,000 (revised) gross. Shipments during May, 1960, amounted to 14,190,000 gross, or 3.7 per cent more than May, 1961. At the end of the first five months of 1961, shipments have reached a preliminary total of 65,247,000 gross. This is 4.1 per cent more than the 62,688,000 gross shipped during the same period of the previous year.

Stocks on Hand at the end of May, 1961, came to 22,273,000 gross. This is 2.2 per cent more than the 21,777,000 gross on hand at the end of April, 1961, and 9.1 per cent more than the 20,422,000 on hand at the end of May, 1960.

GLASS CONTAINER SHIPMENTS
(All Figures in Gross)

Narrow Neck Containers

	May, 1961
Food	1,186,000
Medicinal and Health Supplies	1,368,000
Chemical, Household and Industrial	825,000
Toiletries and Cosmetics	978,000
Beverage, Returnable	1,044,000
Beverage, Nonreturnable	266,000
Beer, Returnable	390,000
Beer, Nonreturnable	857,000
Liquor	1,919,000
Wine	386,000
Subtotal (Narrow)	9,219,000

Wide Mouth Containers

Food	*3,423,000
Medicinal and Health Supplies	363,000
Chemical, Household and Industrial	160,000
Toiletries and Cosmetics	285,000
Dairy Products	97,000
Subtotal (Wide)	*4,328,000
Total Domestic	13,547,000
Export Shipments	*109,000
TOTAL SHIPMENTS	*13,656,000

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

GLASS CONTAINER PRODUCTION AND INVENTORY
(All Figures in Gross)

		Production May 1961	Stocks May 1961
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics.	Narrow Neck	4,521,000	7,196,000
	Wide Mouth	*4,553,000	*7,132,000
Beverage, Returnable		1,041,000	2,786,000
Beverage Nonreturnable		341,000	575,000
Beer, Returnable		348,000	631,000
Beer, Nonreturnable		1,968,000	1,556,000
Liquor		879,000	1,598,000
Wine		476,000	799,000
Dairy Products		97,000	295,000
TOTAL		*14,127,000	*22,273,000

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

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NEW BOOKS

A BIBLIOGRAPHY OF GLASS, compiled by the late George Sang Duncan. Edited by Violet Dimbleby. Oceana Publications, Inc., New York (1960). 544 pages. $45.00.

Contains about 16,000 entries, including references to text books, articles in periodicals, pamphlets, catalogues, and ancient and classical literature.

This comprehensive bibliography was sponsored by the Society of Glass Technology and represents the culmination of 40 years of work on the part of Mr. Duncan up to the time of his death in 1948. Professor W. E. S. Turner sums it up well in the Foreword: "The publication marks the completion of one more of those projects planned at Sheffield in the early days of the Department of Glass Technology of the University and the Society of Glass Technology for making information available on the subject of glass technology. A comprehensive and trustworthy Bibliography is indeed an important tool for all who value sound scholarship and who desire to plan their own investigations with an understanding of all that has already been done in the field selected."

In addition to the 16,000 entries there is a detailed Subject Index which provides a valuable cross reference and makes the book extremely workable for student, glass man, and researcher.

AIR POLLUTION MANUAL, published by the American Industrial Hygiene Association, Detroit, Mich. (1960). 194 pages. $5.50 to members, $8.50 to nonmembers.

This book has been prepared by a group of engineers, chemists, toxicologists, physicists, meteorologists, and other specialists whose common fields of concern are industrial hygiene and air pollution. The book is written as a practical source of information directed toward the actual problems which may be encountered. Some of the major chapter headings include: 1. Legislative and Administrative Procedures, 2. Community Relations, 5. Effect of Air Pollution on Vegetation, 9. Stack Sampling (instruments for measuring gas velocities in stacks, methods of measuring, etc.) and 11. Odors.

COATED ABRASIVES—MODERN TOOL OF INDUSTRY, prepared by the Coated Abrasives Manufacturers' Institute, New York. Published by McGraw-Hill Book Co., Inc. (1958). 426 pages. $8.50.

A guide to the use of coated abrasives in industry, including descriptions and characteristics of each, their advantages, applications, and efficient methods of use.

Of special interest to glass manufacturers is the chapter on grinding and polishing glass (types of machines and methods of grinding, and selection of coated abrasives for grinding and polishing glass).

SEQUENTIAL ANALYSIS

(*Continued from page* 438)

will accept the production segment. As few as 55 samples could accept the segment if no defectives are found. If the quality is as poor as 5 per cent defective, examining an average sample size of 58 pieces will reject the segment and indicate process adjustment. A higher per cent defective than 5 per cent will enable the inspector to decide with decreasingly fewer samples, as the true segment per cent defective increases. In this manner, highly defective production segments are limited to fewer and fewer pieces. Under the most indecisive circumstances (the true per cent defective is actually 2.5 per cent), the average sample size will be 98 pieces, still 35 per cent less than the sample size in the corresponding single sampling plan.

References

[1] *Sampling Procedures and Tables for Inspection by Attributes*, MIL-STD-105 B, U.S. Government Printing Office, Washington, 1959.

[1, 2] H. F. Dodge and H. G. Romig, *Sampling Inspection tables*, John Wiley and Sons, New York, 1944.

[3] *Sequential Analysis of Statistical Data: Applications*, Statistical Research Group, Columbia University, Columbia University Press, New York, 1945.

THE TARIFF SITUATION

(*Continued from page* 432)

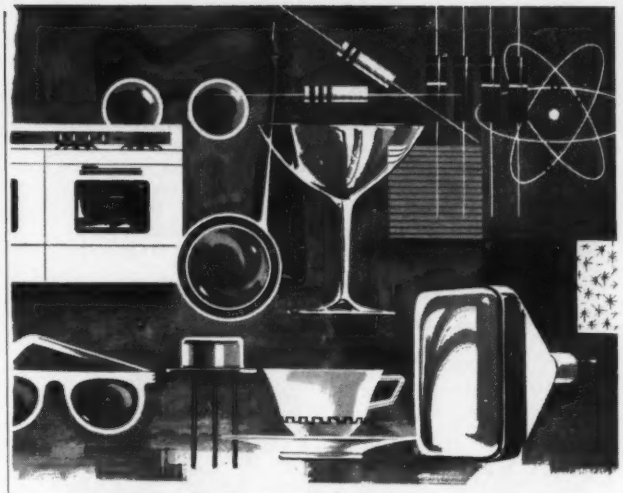
sheet glass in the United States for 30 years, always hearing "the same refrain" from American producers. He contended that imports have helped, not hindered, the domestic industry. Lambert noted that surface improvements effected by Univerbel, a Belgian company, permitted use of sheet glass for purposes where plate glass had been used previously, thus creating new markets. Later, he said, American producers followed suit.

PPG and LOF "have every business incentive to promote the production and sale of the more expensive plate glass and the more lucrative plate glass, rather than the less expensive heavy sheet glass," Lambert said. "Furthermore, they have long invested heavily in costly plate glass production facilities."

Lambert denied that imports increased in 1955-56 and in 1959-60 because of tariff concessions. He said that in both instances the increase was "the direct result of the inability of American sheet glass manufacturers to meet U.S. market demand." He pictured American customers rushing to Belgium begging for "any kind of glass at any price."

Lambert went on to say that American producers have vast distribution advantages and that governmental auhorities here favor domestically produced glass. He cited ocean freight costs, freight in Belgium itself, marine insurance, heavier packing, breakage, and terms of payment as all favoring domestic producers.

The Commission also heard arguments against raising tariffs from Marvin I. Langsam, president of C. M.



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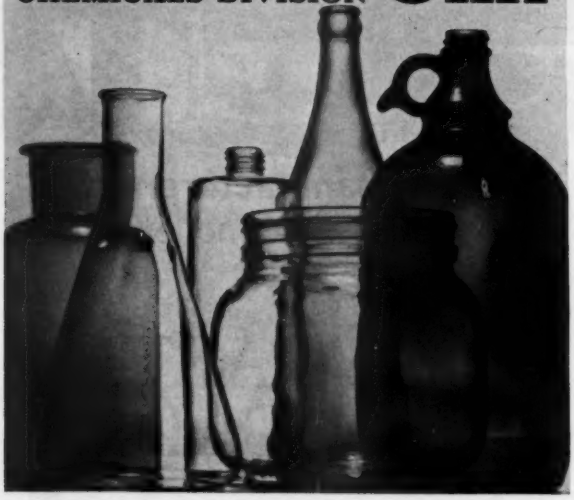

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Whitney Co., an importing firm, representing Japanese and Swedish interests; Bernard P. Harris of Pacific Manufacturers' Export Co., Long Beach, Calif., which represents Asahi Glass Co. on the Pacific Coast; Maurice Levy-Hawes of International Economic Consultants, Inc., Washington, D.C.; and Miles W. Kirkpatrick of Philadelphia, representing Pilkington Brothers, Ltd., Lancashire, England. J. B. Booth of Seaply Glass Corp., New York, and William J. Barnhard, a Washington attorney, represented Finnish and Austrian interests. Barnhard claimed that 1961 figures up to that time had shown Finnish and Austrian shipments down 40 per cent from the January 1960 level.

Booth concluded, "The domestic industry can solve most of its difficulties by making what is marketable instead of marketing what they make."

GLASS DIVISION PAPERS

(*Continued from page 448*)

coordination. It was compatible with vanadates, chromates, iodides, and a series of organic dyes which would decompose if introduced into technical glasses of higher melting point.

Variation of the H_2O to Si ratio in the glass affected the compatibility of certain of the inorganic compounds studied. The Na to Si ratio, however did not appear to be so important, because it can be varied considerably without visibly affecting the nature of the glass.

Some Remarkable Effects of Pressure (Up to 200,000 Bars) on the Structure of Glass. By Howard M. Cohen and Rustum Roy, Pennsylvania State University. Presented by Cohen. The densities and refractive indices of glasses of SiO_2, GeO_2, B_2O_3, "window", $PbSiO_3$, etc., were increased remarkably by the application of pressures from 2000 to 200,000 bars. This change attained an "equilibrium" value almost instantaneously (15 to 30 seconds) at a given pressure and temperature. Moreover, the density increment for a given pressure increased sharply with temperature in the range from –100°C to 600°C. The magnitude of the density changes was over 20 per cent in SiO_2 glass at 150,000 bars. While the refractive index of SiO_2 glass was 1.48 at 40 kb and 200°C, it was 1.52 at 40 kb and 500°C. The influence of composition, temperature, pressure and time was studied systematically, and an explanation was advanced based on a continuous structural change with an essentially fixed activation energy of transformation quite independent of the instantaneous "compressibility."

The Effect of Water Vapor on the Kinetics of the Crystallization of Silica Glass. By Frank E. Wagstaff, Ivan B. Cutler, and Sherman D. Brown, University of Utah. Presented by Cutler. The kinetics of the transformation of silica glass to cristobalite were studied by measuring the movement of the crystalline interface microscopically. Samples, in the form of ⅛-in. rods were periodically removed from a furnace, held at con-

stant temperature, quenched, mounted, and polished. The rate of crystal growth was calculated from isotherms in the temperature range 1300°C to 1600°C. The growth rate was significantly increased by water vapor atomospheres both from within and from outside the glass.

The Dielectric Properties of Neo-Ceramic Glasses in the Systems Bi_2O_3.CdO.SiO_2 and Bi_2O_3.CdO.B_2O_3 and their Relation to the Structure of Glass. By V. J. Rao, International Resistance Co. Areas of glass formation and regions of neo-ceramic glasses in the systems Bi_2O_3.CdO.SiO_2; Bi_2O_3.CdO.B_2O_3 were determined. Properties of select glass compositions in the neo-ceramic regions were determined before and after nucleation and heat treatment. The results showed no maxima or minima in dielectric properties vs. composition curves. The dielectric constant increased after heat treatment, and the dissipation factor demonstrated a remarkable change toward higher values. Glasses with Bi_2O_3.CdO as the main constituents exhibited unusual K values ranging from 30 to 50. Because these glasses contained only from 0.5 to 2.0 per cent by weight of SiO_2 or B_2O_3, the conventional concept of glass structure composed of a random spacial network of SiO_4 tetrahedra, whose interstices are filled with network-modifiers, cannot be sustained in this instance.

It was postulated that the dominant cations Bi^{3+} and Cd^{2+} form the network, and the interstices are occupied by Si^{4+} cations acting as network modifiers. It also appeared possible that Si^{4+} may have a coordination number greater than 4. The dielectric losses were explained in terms of the relative weakness of the structure.

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